POWER

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IN THESE DAYS of high excitement, when all eyes are on our fleet,
And much homage on our sailors we bestow,
Let us not forget to honor and to give due share of praise
To the boys who swing the shovels down below.

THEIR DEEDS may lack the glitter of the men above the deck,
As they toil and sweat deep down within the hold,
But their courage is as noble and their service is as great,
Though the valor which they show is seldom told.

THEY DO NOT SHOOT torpedoes and they do not work the guns,
But they fit as much into the general scheme,
For you cannot fight a battle and you cannot chase the foe
Unless you have a good supply of steam.

WHILE, ABOVE, the battle rages, you will find them on the job,
Sweating blood and grimly hanging to their task;
And if the good ship founders, then their hope of life is small,
But the chance to serve their country's all they ask.

SO IN VICTORY or disaster give these boys their honor due,
Count them heroes in a land where heroes grow;
And remember that our Navy has no braver names enrolled
Than the boys who swing the shovels down below.

Multi-Stage Compression Plant of Central Cold Storage Co.

Modern two-unit ammonia plant of 500 tons refrigerating capacity employs new D. I. Davis system of multi-stage compression with cooling of vapor between stages. It is expected to save in power 25 per cent. over the standard simple compressor and to develop one ton of refrigeration on less than 25 lb. of steam per hour.

FOR low-temperature work where brine temperatures running below zero are required, the standard compression plant has not been looked upon with favor. Boosters have been employed to increase the capacity of the compressor, but more often this class of work has been regarded as belonging to the absorption plant. The poor economy of the compression system in this work is due to several factors, developing as a direct result of the low suction pressures corresponding to the low temperatures in the refrigerator. As the suction pressure is reduced, there is a rapid falling off in the capacity of the compressor without a corresponding reduction in the power required. At lower suction pressures the ammonia vapor occupies more space and the volumetric efficiency is reduced. For example, with a suction pressure of zero, one pound of ammonia would occupy about 17.6 cu.ft.; with a 30-lb. suction pressure, only 4.5 cu.ft. For these reasons the standard single-cylinder compressor was both uneconomical and expensive for low temperatures.

In the development of the compression system[1] devised by D. I. Davis, of Chicago, and perfected commercially by the Vilter Manufacturing Co., the above objections have been eliminated and extremely low temperatures can be economically produced. The outstanding features of the new system are multi-stage compressors and the cooling of the vapor between stages by the refrigerant to a temperature corresponding to the saturation point for the intermediate pressure. The use of two cylinders decreases the temperature range per cylinder with the attending advantages, and reduces the heat of compression. The cooling between stages permits of making the high-pressure cylinder smaller and keeps down the temperature of the discharge to the condenser.

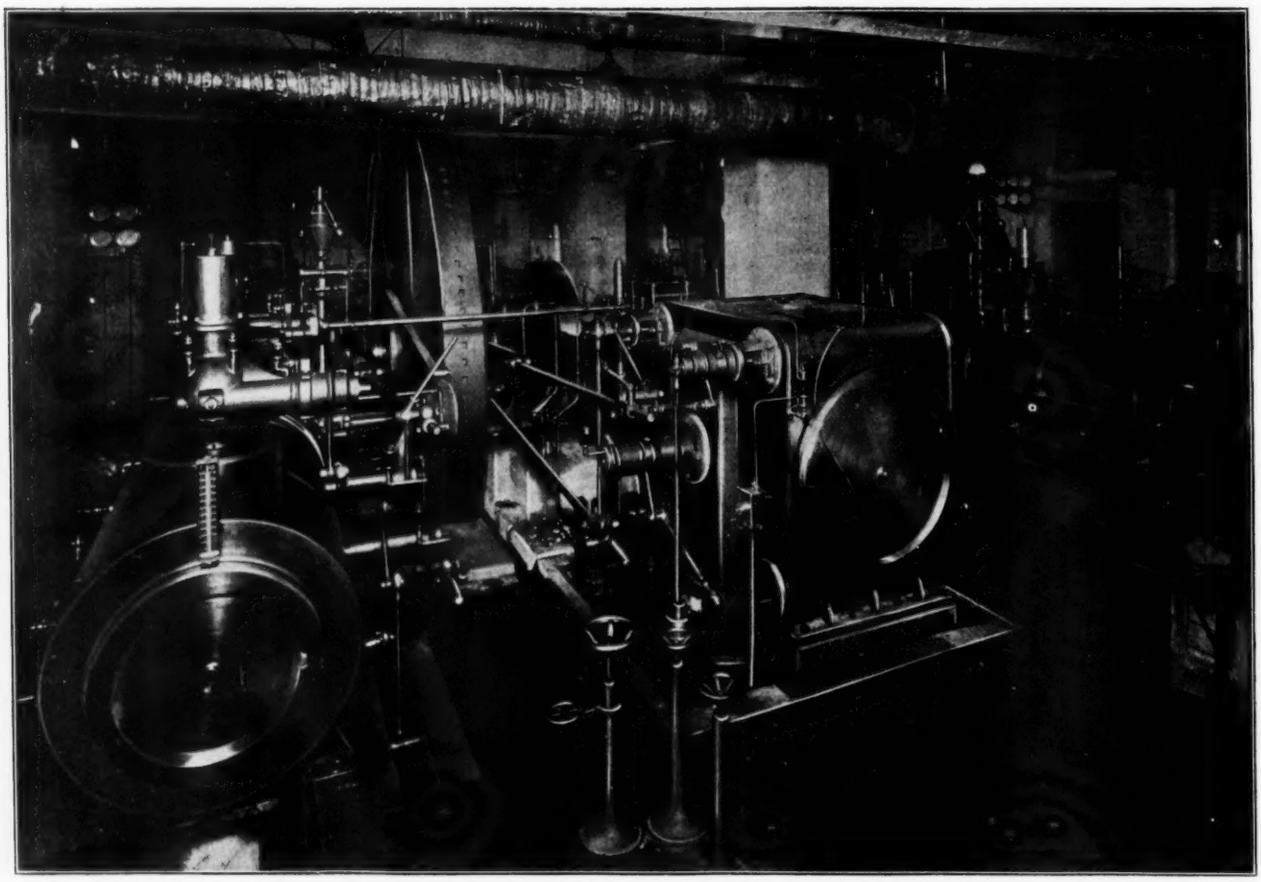

FIG. 1. STEAM END OF ONE OF THE 250-TON COMPRESSORS

A two-unit 500-ton plant of this type has been installed recently by the Central Cold Storage Co., Dearborn and Kinzie Sts., Chicago. The building is a 14-story structure of steel and reinforced concrete faced with brick. It is adjacent to the Chicago & North

[1]See "Power," Dec. 19, 1916, p. 844.

Western R.R. tracks, has excellent facilities for teaming and is a short distance from the Chicago River, from which feed water for the boilers and condenser cooling water is obtained. The building contains over 9 acres of floor area and 3,500,000 cu.ft. of cold storage.

The first floor is given over to receiving and shipping. Cooling rooms in which the temperature ranges from 30 to 40 deg., depending upon the product stored, occupy the second to the eighth floors inclusive, and from the ninth to the fourteenth floors are freezers with temperatures of 10 deg. below zero maintained by brine circulated at temperatures ranging from 18 to 22 deg. below zero.

The building has a total of 39 refrigerated rooms. It is divided into six independent sections and is equipped with 60 miles of 2-in. piping for circulating the brine. In each room the coils are divided into sections, and only as many sections as are needed to give the desired temperature are used. Temperature regulation is effected in this way rather than by varying the temperature or circulation of the brine.

To insulate the building required more than 1,500,000 board feet of corkboard. The insulation runs continuously from the second floor to the top of the roof slab. The first layer of cork was bonded to the brick surfaces of the walls by a ½-in. bed of portland-cement mortar. The second layer of cork was then erected against the first in a bed of hot asphalt and held in place by hickory dowel pins. All joints of the second course were broken, with respect to those of the first, and sealed with hot asphalt. All exposed surfaces throughout the building were finished with two coats of portland-cement plaster to a thickness of ⅝ inch.

All exposed wall areas from the second to the ninth stories were insulated with 5 in. of cork and wall surfaces abutting adjoining buildings with 4 in. of cork. From the ninth story to the roof where the freezers are located, 6 in. of cork, composed of two layers of 3 in. each, is used. Two partitions running from the second floor to the roof and dividing the building into three distinct sections, also have 6 in. of cork. The entire second floor was insulated with 4 in. of cork in two layers, and the third-floor ceiling over the offices and display rooms has 5 in. of cork insulation laid in concrete forms and suspended from the under-ceiling slab. The ninth floor is insulated also with 5 in. of cork in 3-in. and 2-in. layers laid in concrete forms, bound together with ½ in. of portland cement and adhered to the concrete

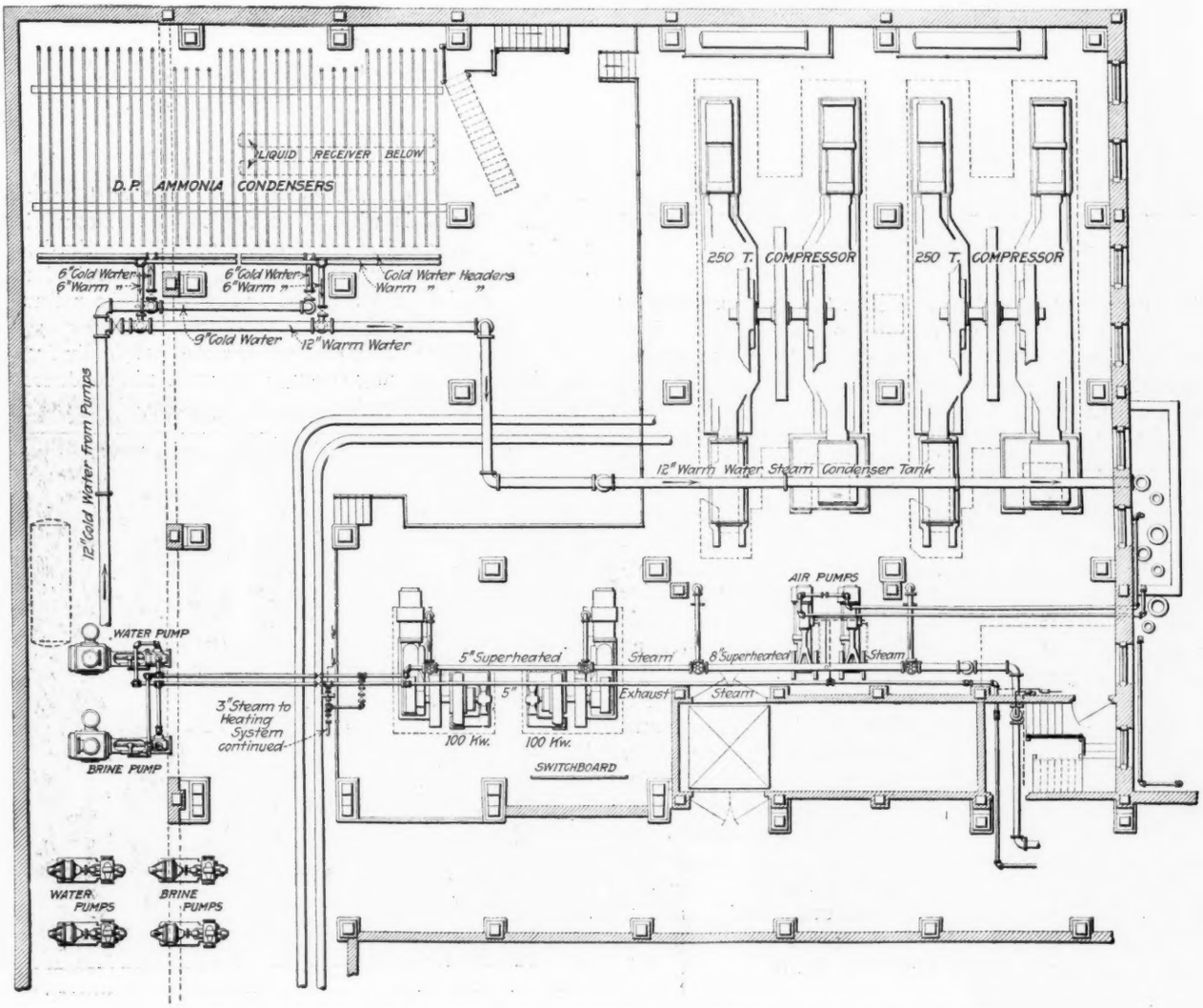

FIG. 2. LAYOUT OF EQUIPMENT, CENTRAL COLD STORAGE CO., CHICAGO, ILL.

slab when it was originally poured. The roof area was insulated with two layers of corkboard, one 4-in. and one 3-in., laid in hot asphalt and covered with seven-ply built-up roofing. The building columns from the footings in the sub-basement to the third-floor slabs are covered with two 2-in. layers of cork. Forms were then placed around the insulated steel columns and a layer of concrete poured over the cork.

In the sub-basement of the building is the refrigerating plant, the general layout, with the exception of the

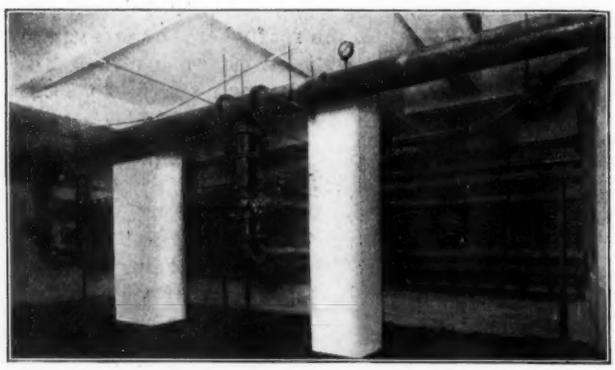

FIG. 3. DOUBLE-PIPE CONDENSERS

boiler room, being shown in Fig. 2. The compressors are of the double-acting cross-compound type. The low-pressure cylinder, or the first stage of the compressor, is 28-in. diameter by 48-in. stroke, while the diameter of the high-pressure cylinder is 20½ in. The compressor is directly connected to a cross-compound condensing engine, 20 and 42 by 48 in., the high-pressure cylinder being of the poppet-valve type designed for superheated steam and the low-pressure cylinder equipped with standard Corliss valve gear. The speed is 60 r.p.m. The flywheel is 18 ft. diameter and weighs approximately 28,000 lb., as compared to 300,000 lb. for the entire unit. The floor space occupied by each unit is approximately $18 \times 46 = 828$ sq.ft., or 3.3 sq.ft. per ton of refrigerating capacity.

Both compressors and engines are equipped with a central oiling system with telescopic oilers on crank and crosshead pins and sight feeds on other bearings. The oil is supplied by gravity from an overhead tank. The surplus from the bearings is drained to a tank below the floor level and pumped back through a filter to the overhead tank. There are also force-feed pumps for cylinder lubrication and sight-feed oilers for the exhaust-valve levers of the high-pressure steam cylinders.

The steam end of each unit is supplied with a barometric condenser, giving about 27½ in. of vacuum, and the compressor end has a double-pipe ammonia condenser. The latter has 12 sections 12 pipes high, made up of 2- and 1¼-in. pipes 20 ft. 6½ in. long. The condenser is divided to give satisfactory distribution of the water, which is drawn from the river by any one of three circulating pumps. Two are centrifugal pumps, one for each unit, each having a capacity of 1000 gal. per min. and driven by a 40-hp. motor, while the third is a direct-acting 16 and 20 by 20-in. simplex steam pump. Under normal conditions, each condenser requires about 635 gal. of water per minute. After the water has passed through the ammonia condensers, part of it passes to a large tank between the second and third floors for boiler feeding and the balance through the barometric condensers back to the river.

Calcium-chloride brine of density 1.260 is used. Its temperature is lowered to 22 deg. F. below zero in four brine coolers of the horizontal shell type, two being provided for each compressor. Each cooler has twelve sections and a capacity to care for 150 tons of refrigeration. The brine is circulated through the house and discharged into an open tank on the top floor, returning thence to the pumps and again passing through the same cycle. The system is thus practically balanced, with only a 20-lb. friction head to overcome. In type, capacity and number, the brine pumps are the same as those used to circulate the condenser water, with the exception that the centrifugals are driven by 30-hp. motors.

Steam is supplied to the plant by two 400-hp. Stirling boilers generating steam at 175 lb. pressure and 103 deg. superheat. The boilers are served by chain grates and natural draft is supplied by a steel stack 6 ft. 4 in. diameter and 195 ft. 4 in. high above the boiler-room floor. Coal comes in on the railway tracks serving the building and is dumped directly into the coal bunker underneath and is wheeled to the boilers. From pits under the stokers the ashes are shoveled into the boot of a bucket elevator discharging into a concrete tank on the second floor, with a chute leading to the railway cars.

As previously stated, feed water comes originally from the river, first passing through the ammonia condenser,

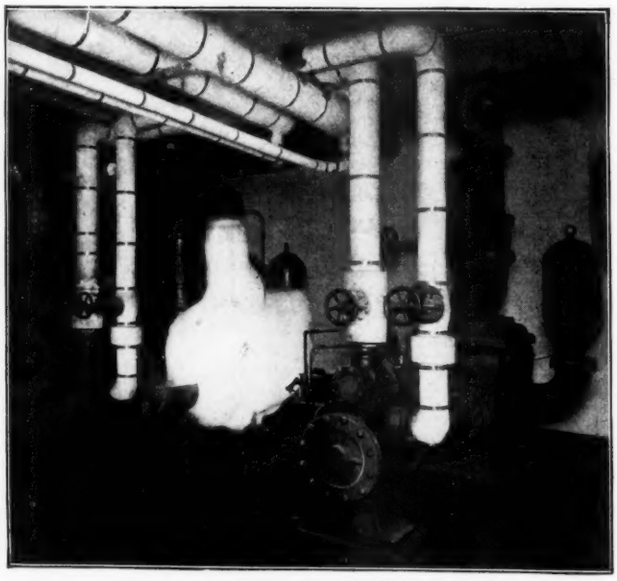

FIG. 4. BRINE AND WATER CIRCULATING PUMPS

then to a large storage tank and finally under float control to an 800-hp. open heater. Duplicate simplex feed pumps, 10 and 6 by 12 in. take the water from the heater and feed it to the boilers. At each boiler is a manifold, from which the feed may be supplied to the boiler through a ¾-, 1- or 1¼-in. valve, the choice of valve depending upon the rate at which the boiler is being driven. In this way the demand for water can be followed closely and the pump maintained in constant operation, with little need for regulation.

To supply electric light and power to the six electric elevators serving the building and to the motors driving the pumps, fans and ash hoist, two 100-kw. direct-current generating units have been installed. The ammonia-compressor engines are of the uniflow type, 15 x 17 in. At the time of the writer's visit, one of the barometric condensers was serving a compressor engine and the two lighting units. The vacuum approximated 27½ in. The generators are directly connected to the high-pressure cylinder and is further compressed to a condenser pressure of 165 lb. It is necessary to cool the liquid ammonia coming from the condenser to a temperature corresponding to its evaporation point before it can do useful work. Instead of doing all this in the refrigerator, or in this case the brine coolers, the liquid is passed through the liquid ammonia cooler, previously referred to, located between the condensers and the brine coolers. Ammonia from the liquid re-

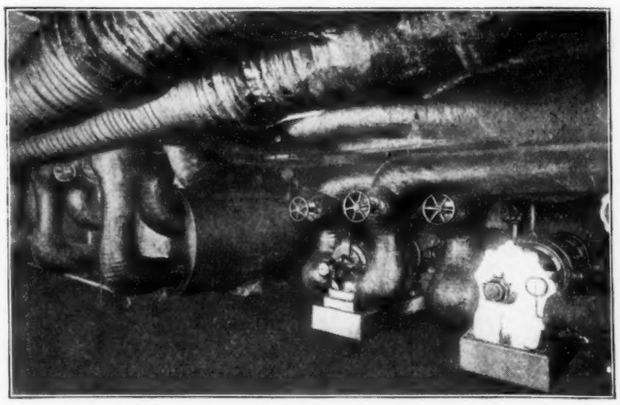

FIG. 5. CENTRIFUGAL BRINE PUMPS AND BRINE COOLERS

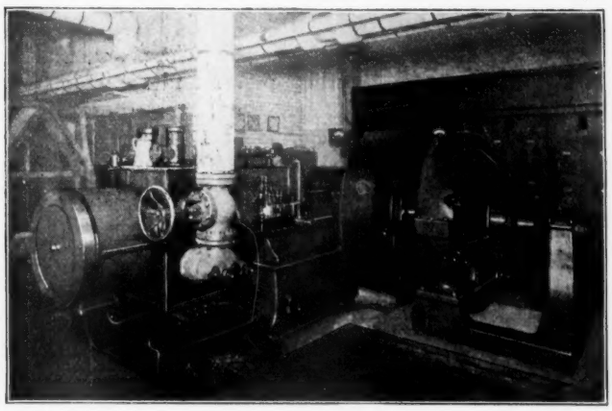

FIG. 6. ONE OF THE 100-KW. ELECTRIC GENERATING SETS

and are rated to deliver 400 amp. at 240 volts. The load runs as high as 700 amp., so that the two units are frequently required.

Having reviewed the equipment of the plant, the ammonia cycle may be followed more clearly. Ammonia vapor from the brine coolers is drawn to the low-pressure cylinder of the compressor at a pressure of 1 to 4 lb. From the low-pressure cylinder it is passed to an intermediate drum having a pressure of 25 to 30 lb. The vapor heated by this compression is cooled by wet vapor coming from a liquid cooler located between the condensers and the brine coolers. There is also means of introducing liquid ammonia into this drum if required and a trap to return excess liquid to the liquid cooler. The vapor cooled to the temperature corresponding to the saturated point at this pressure then passes ceiver at the condenser is expanded into the cooler and is returned to the high-pressure cylinder through the intermediate drum as previously explained. Coming from the condenser the liquid ammonia has a temperature of 90 deg. F., and when leaving the heat exchanger or liquid cooler, its temperature is reduced to 17.5 deg. F. This drop in temperature of 72.5 deg. is effected with a suction pressure of 25 to 30 lb. instead of the 1 to 4 lb. for the low-pressure cylinder. In the brine coolers the liquid must be cooled to its evaporating temperature, a comparatively small range. It is apparent that considerably less vapor than in the usual compression system must be handled by the low-pressure cylinder. It can therefore be made smaller and the power required per ton of refrigeration will be less.

Unfortunately, no complete test data are as yet avail-

PRINCIPAL EQUIPMENT OF CENTRAL COLD-STORAGE REFRIGERATING PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Conpressors	Two-stage	20½x28x48-in.	Compress ammonia vapor	Suction press., 1 to 48 lb.; discharge, 165 lb.	Vilter Mfg. Co.
2	Engines	Cross-compound	20x42x48-in.	Drive compressors	Steam press., 175 lb., 103 deg. superheat, 60 r.p.m.	Vilter Mfg. Co.
2	Condensers	Barometric	9,000 lb. steam per hr.	Serve compressor engines	27- in. vacuum	Vilter Mfg. Co.
2	Pumps	Vacuum	6½x10x12-in.	Serve steam condensers		Union Steam Pump Co.
2	Condensers	Double-pipe	12 sections, 12 high.	Serve ammonia compressors	165 lb. pressure	Vilter Mfg. Co.
4	Brine coolers	Shell-type	150 tons ref.	Cool brine	Outgoing temp., 22 deg., incoming, 16 deg.	Vilter Mfg. Co.
2	Pumps	Centrifugal	1,000 gal. per min.	Circulate brine	Driven by 30-hp. Crocker-Wheeler D.C. motor.	A. S. Cameron Steam Pump Works
1	Pump	Simplex	16x20x20-in.	Circulate brine		American Steam Pump Co.
2	Pumps	Centrifugal	1,000 gal. per min.	River Water to Am. cond.	Driven by 40-hp. Crocker-Wheeler D.C. motor	A. S. Cameron Steam Pump Works
1	Pump	Simplex	16x20x20-in.	River water to Am. cond.		American Steam Pump Co.
2	Engines	Uniflow	15x17-in.	Drive generators	Condensing, 200 r.p.m.	Chuse Engine & Mfg. Co.
2	Generators	Direct-current	100 kw.	Generate electric current	240-volts, 400 amp., 200 r.p.m.	(Western Electric) General Electric Co.
2	Boilers	Stirling	400 hp.	Generate steam	175 lb. press., 103 deg. superheat	Babcock & Wilcox Co.
2	Stokers	Chain-grate	80 sq.ft.	Serve boilers		Babcock & Wilcox Co.
2	Superheaters	B. & W.		Serve boilers	103 deg. superheat	Babcock & Wilcox Co.
1	Stack	Steel, lined	6 ft. 4 in. diam., 195 ft. high	Serve boilers		American Bridge Co.
2	Pumps	Simplex	10x6x12-in.	Boiler feed		American Steam Pump Works
1	Heater	Open	800 hp.	Heat feed water	Exhaust steam from auxiliaries	Platt Iron Works
1	Pump	Simplex	7x4½x10-in.	House pump		American Steam Pump Works
1	Pump	Simplex	4x4x8-in.	Vacuum pump for office heating		American Steam Pump Works

Insulation, "Crescent" corkboard installed by United Cork Companies; Nugent Central oiling system and filter for compressor units; Richardson-Phenix force-feed lubricators for cylinders; Powell sight-feed lubricators for exhaust valve levers of high-pressure steam cylinders; Hills-McCanna force-feed lubricators for uniflow cylinders; Jenkins steam valves; Jenkins water valves; New Bedford stop and check valves; Gato blow-off valves; Crosby safety valves; American steam traps; Vilter refrigerating valves and piping.

able. For three months previous to the present writing the plant had been in operation, carrying at least 3,000,000 cu.ft. of storage space. This load has never required more than one machine, and the usual practice is to run this one machine about 16 hours out of the 24. If the compressor is developing its rated capacity, 12,000 cu.ft. of space is being refrigerated per ton of refrigeration, with the compressor running two-thirds of the time and approximately one-half the space for low-temperature work, 10 deg. below zero in the freezers and brine at —18 to —22 deg. F. The temperature of the returning brine ranges from —12 to —16 deg. F., giving a rise of 6 deg. F. through the house. The average daily coal consumption for lighting, power and refrigeration has been as follows: July, 12.2 tons; August, 12 tons; September, 10 tons. On a basis of 11.4 tons per day, the average for the three months, 950 lb. of coal would be burned per hour. Of this it is estimated that 240 lb. is required by the generating units, leaving 710 lb. of coal per hour for the compressors, air pumps serving the condensers and the brine and water circulating steam pumps. This reduces to 2.84 lb. of coal per hour per ton of refrigeration, or with an evaporation of 8 lb. of water per pound of coal, 22.7 lb. of steam. From previous test data it is expected that the steam requirement per hour per ton of refrigeration will be held close to 20 pounds.

While the figures given are only approximate, it is evident that exceptional efficiency is being obtained not only from the refrigerating plant, but from the insulation as well. Test data, to be available soon, will be received with interest.

D. I. Davis and Co., architects and engineers, designed the plant and the refrigerating equipment was installed by the Vilter Manufacturing Co. L. E. Gibbons is chief engineer in charge of operation.

Suspended Templets and Their Application*

BY TERRELL CROFT

Something about suspended templets for use where large foundations are to be constructed. Their advantages are pointed out, and various methods of suspending them are shown.

A SUSPENDED templet may be defined as one that is supported over and at a considerable distance above the foundation for which it is to locate the anchor-bolt positions. Fig. 1 gives a graphic definition, wherein *A* is the suspended templet hung from the roof-truss chords over the foundation excavation immediately below it. The applications for which suspended templets are desirable are those where a very large foundation or one that will contain a considerable number of anchor bolts is to be constructed. A templet of this character may, where the excavating is to be done by, and the foundation material to be handled with cranes, insure more economical construction. The reason is that the templet is supported in such a position that the movement of the material will not displace it or displace the foundation-bolt locations which it determines. Furthermore, it cannot be displaced by careless workmen or by material dumped from the cranes. The disadvantage of the suspended templet is that it is more expensive to erect than is one which is supported directly over and by the forms for the foundation.

The method of locating anchor-bolt positions with a suspended templet may be understood by a consideration of Fig. 1. The templet, *A*, has a small hole bored through it over each of the anchor-bolt locations. When it is desired to locate an anchor-bolt position in the foundation under construction, a plumb-bob is fastened successively to each of the cords *D*, which are dropped through the hole in the templet above; thus the pocket *B*, which is to be provided under each anchor bolt, is located. The form for the pocket is constructed in its proper location on the foundation footing, and the anchor plate, if it is to be built into the foundation, is placed in position. The forms for the pockets may be of either brick or wood. Each anchor plate is centered on the top of the pocket under the plumb-bob *E* suspended from above.

The forms are then constructed and the anchor-bolt casings *C* are placed to provide holes through the foundation for the anchor bolts. The anchor bolts are not inserted until after the foundation has been completed and the machinery which is to be mounted on it has been set in position. The anchor-bolt casings are supported at their bottoms by the anchor plates or by the upper faces of the pocket forms. At its top each anchor-bolt casing is braced to the top of the foundation form. The location of the top of each casing is, after it has been erected, checked again by plumbing down from the templet above. When the drop-lines from the templets are not in use, they are tied up high enough to be out of the way. When the crane is to be used, all the drop-lines must, of course, be pulled clear up above the templet so that they will not interfere with the movement of the crane. The plumb-bobs on the drop-lines are used only for transferring the points down from the templet to the foundation while the forms are being erected and to check the accuracy of the locations as the installation progresses.

In constructing templets for suspension, practically the same methods are followed as are used in assembling the templet for any large foundation. Ordinarily, the templet is made of planed 1-in. planks fastened together with screws. It is first laid out and assembled either completely or in sections in the carpenter shop. Then it is carried to the building where it is to be suspended and either put together on the floor to form a complete unit and raised to its position under the roof trusses, or it may be raised in sections and then assembled on the timbers provided for its support just under the roof-truss bottom chords.

In locating the templet in its position under the roof-truss chord, the principal center lines are, by means of a transit, transferred from some reference point, either on a roof truss, side wall or column, to

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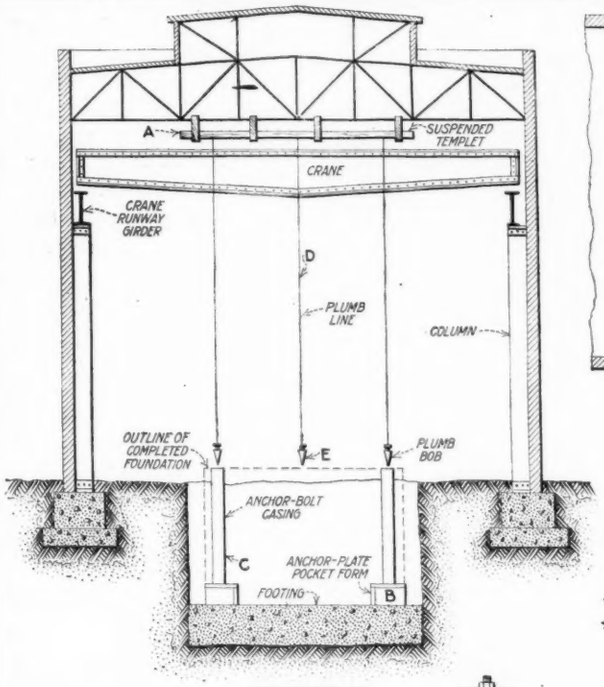
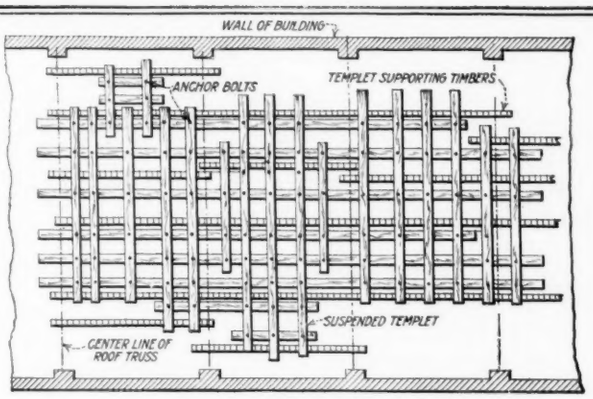


FIG. 1 APPLICATION OF SUSPENDED TEMPLET



PLAN OF SUSPENDED TEMPLET IN PLACE IN A MILL BUILDING

FIG. 2

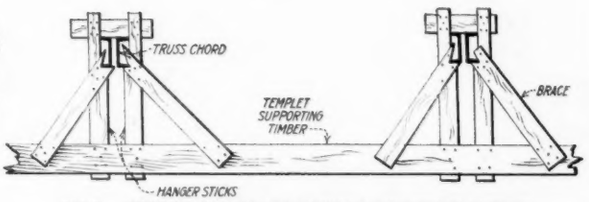
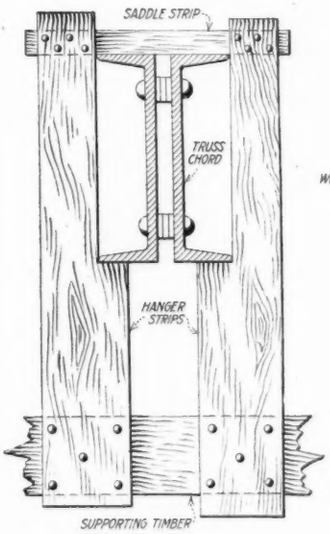
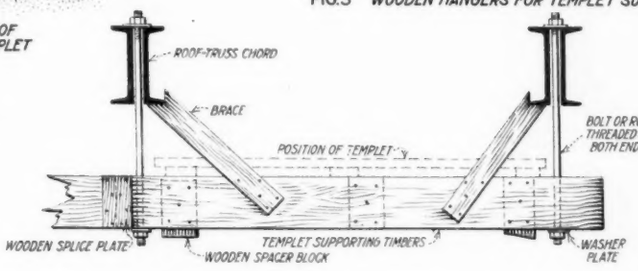


FIG. 3 WOODEN HANGERS FOR TEMPLET SUPPORTING TIMBERS



ONE METHOD OF HANGING SUPPORTING TIMBERS FROM TRUSS CHORDS

FIG. 4



TEMPLET SUPPORTING TIMBERS HUNG FROM ROOF-TRUSS ON BOLTS

FIG. 5

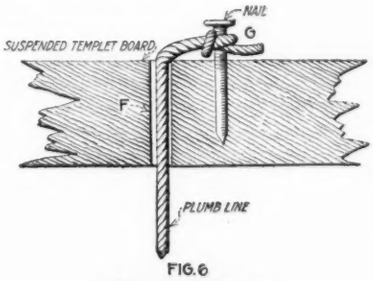


FIG. 6

METHOD OF ATTACHING PLUMB LINE TO TEMPLET

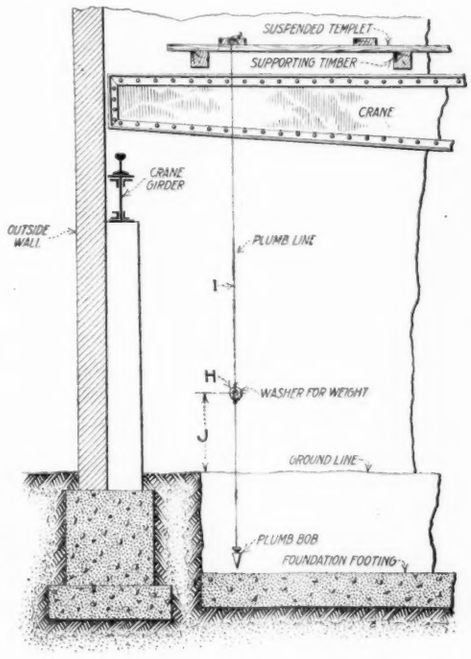


FIG. 7

APPLICATION OF WEIGHTED PLUMB LINE

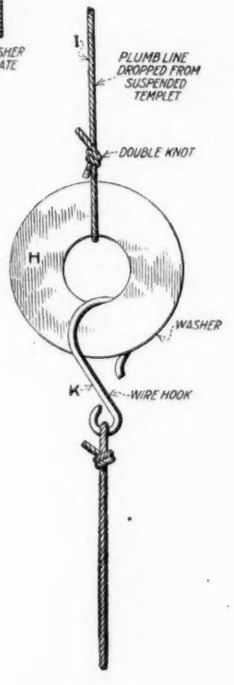


FIG. 8

DETAIL OF WASHER WEIGHT AND PLUMB BOB HOOK CONNECTION

FIGS. 1 TO 8. APPLICATION OF SUSPENDED TEMPLETS

the templet itself, which must then be shifted on the timbers which hold it on the trusses until the templet has been accurately located in its position. A transit should be used, as just described, to center the templet both longitudinally and transversely. At the same time the principal center lines should be marked on some permanent member, such as a roof truss or wall, near the suspended templet so that the position of the suspended templet can, in the future, be checked for accuracy if necessary.

How templets are supported from the roof trusses is shown in Figs. 2, 3, 4 and 5. The planks upon which the templet rests (Fig. 3) are called templet-supporting-timbers. These have been shown shaded in the diagram of Fig. 2 so that they may readily be distinguished from the templet itself. These timbers are hung from the roof truss chords (Figs. 3, 4 and 5) and are braced in all directions so that they cannot shift after the templet has once been located in position and pinned to them with nails. For hangers, either portions of planks, bolts or iron rods threaded on both ends may be used.

Wooden hangers for templet-supporting timbers are assembled so that they form a yoke or tie over the roof-truss lower chords, as shown in Fig. 4. The assembly of Fig. 3 shows a templet-supporting timber sustained from each of two truss chords with wooden hangers. The braces provided to prevent longitudinal movement are also indicated in this illustration.

Hanger Bolts for Supporting Timbers

Bolt hangers for templet-supporting timbers may be employed as detailed in Fig. 5. The bolts thus used are available for other services after the foundation has been completed; $\frac{3}{8}$-in. rods threaded and provided with nuts on both ends constitute good tension rods for this service. Where hanger bolts are employed, two sticks with wooden separators between them are used to make up each girder. The bolt then passes through the space between the two timbers. A thorough system of bracing must be used to prevent any possibility of the shifting of the templet-supporting timbers. In Fig. 5 the position which the templet would occupy has been shown by dotted lines.

The best material for the drop-lines is a medium-weight linen fishline. Brown manila twine is probably next best. Ordinary white cotton twine is not satisfactory because it is not sufficiently strong.

The method of attaching the drop-lines to the templet is detailed in Fig. 6. *F* is a hole $\frac{3}{32}$ or $\frac{1}{8}$ in. diameter through which the drop- or plumb-line is passed to the foundation below. Into the templet near each hole a nail *G* is driven, to which the upper end of the plumb-line can be tied.

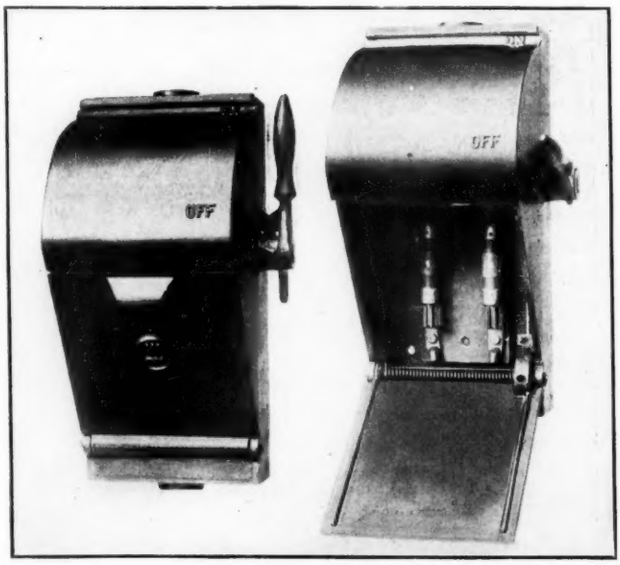
The drop-lines should be weighted at their lower ends to prevent them from becoming tangled with one another. Punched washers of sheet steel constitute excellent weights for this purpose. A washer *H* (Fig. 7) may be tied on the lower end of each drop-line *I*, as shown. The washers may be located at such a distance *J* above the surface of the ground that they can be readily reached; that is, it is not necessary or desirable to have the drop-line extend for the entire distance to the bottom of the foundation excavation. When an anchor-bolt location is to be determined, the plumb-bob line, which is provided with a hook *K* (Fig. 8), can be hung on the end of the main drop-line until the bolt location has been fixed. Then the plumb-bob line can be unhooked and carried to the next bolt location.

Safety-First Knife Switch

In all places employing men with practically no knowledge of electricity and its attendant risks, an absolutely safe switch has become a necessity. The real safe switch is one so constructed that all live parts are totally inclosed and inaccessible. Means should also be provided for preventing operation by unauthorized persons.

The switch shown in the figures, brought out by the Westinghouse Electric and Manufacturing Co., of East Pittsburgh, Penn., meets the foregoing conditions. The complete device consists of an ordinary single-throw knife switch and inclosed fuse holders mounted in a cast-iron box, with an operating handle outside the housing. The box is designed for conduit connection and has a partition separating the switch blades from the fuse holders.

The upper, or switch, compartment can be opened only by removing two machine screws and should be opened



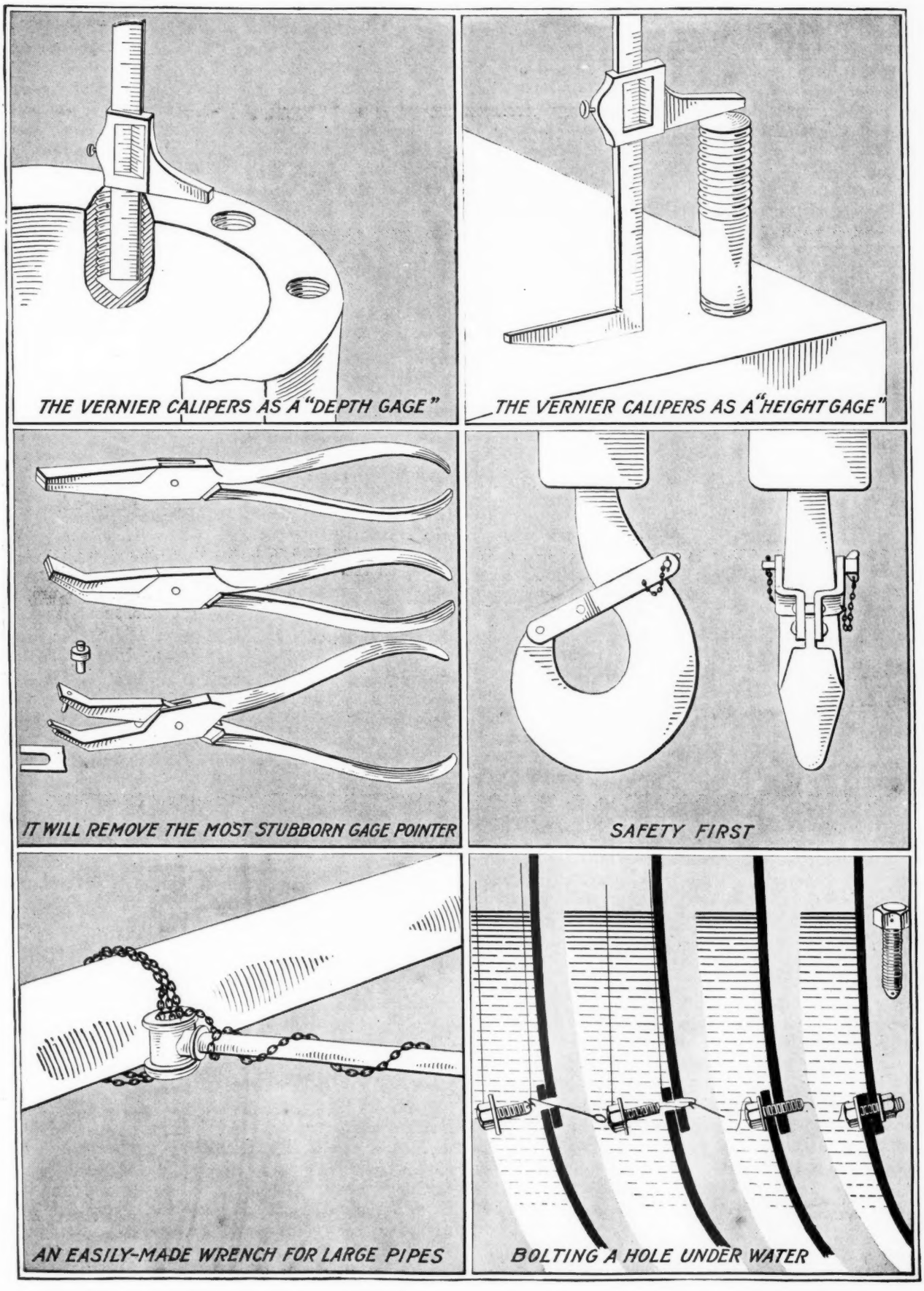
CLOSED AND OPEN VIEWS OF SWITCH

only when making connections or in case of inspection or repairs, as the switch is opened and closed by the operating handle, from the outside.

The lower, or fuse, compartment, containing the fuses and fuse holders, is the only part of the switch that need be opened, and then only to replace blown fuses. The door of this compartment is so interlocked with the switch that it can be opened only when the operating handle is in the off position and the circuit broken. Furthermore, with the door of this compartment open it is impossible to close the switch. The operating handle can also be locked with the switch in the open position, preventing tampering by unauthorized persons.

The City of Philadelphia has the distinction of having operated the first steam-pumped water system in the United States and also of operating the largest pumping plant in the world at present.

Kinks Worth Knowing


THE VERNIER CALIPERS AS A "DEPTH GAGE"
THE VERNIER CALIPERS AS A "HEIGHT GAGE"
IT WILL REMOVE THE MOST STUBBORN GAGE POINTER
SAFETY FIRST
AN EASILY-MADE WRENCH FOR LARGE PIPES
BOLTING A HOLE UNDER WATER

Selection of Coal and Ash Conveyors

BY H. E. BIRCH
Structural and Mechanical Engineer, Philadelphia, Penn.

In selecting the equipment one should strike the best balance of operation, maintenance, investment and adaptability. Roller flight conveyor a desirable type. Flights over 24 in. should have two chains. Scraper conveyors limited to about 300 ft. length. Relative advantages of bucket and belt conveyors are considered.

THERE are four items which should control the selection of coal- and ash-handling equipment; namely, cost of operation, maintenance, interest on the investment and adaptability. These four are the constituent of the "O-M-I-A" formula, which should be applied in all cases to the bidders' competitive designs, to secure a well-balanced plant. A saving of several hundred dollars a year on power may warrant the investment in a more elaborate plant, but possibly this is offset by the greater depreciation factor or by the greater cost for labor required to operate it. All these items should be tabulated and a careful comparison made between the designs offered. The writer knows of one management corporation where the financial department makes the final selection after the engineers have secured all b .

The benefits accruing through the installation of coal- and ash-handling equipment are many, the greatest probably being the saving effected in the wages. But

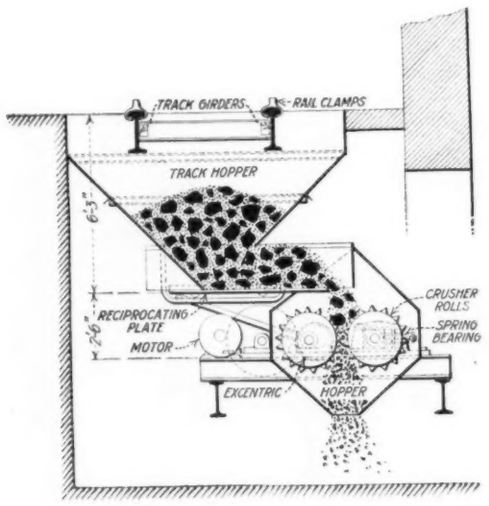


FIG. 1. TRACK COAL HOPPER AND CRUSHER

this is not the only feature. There is the greater freedom from labor troubles, and the ease with which machinery can be managed, as compared with the management of unskilled workers. The unreliability of a large force of poorly paid and unskilled passers and ash men cannot be compared with the reliability of a few intelligent workmen operating well-designed and selected equipment.

Many boiler houses have been equipped with coal- and ash-handling machinery, but many a man is often at a loss as to the type of equipment to install; and it is here that the first most serious mistakes are made.

It is desirable then, at this stage, to get the unprejudiced engineering advice of a coal-handling expert, to avoid building a monument of carelessness which will be costly to operate and maintain.

Realizing the need for service of this nature, several firms of contracting engineers have specialized in this branch, and at least one of them further attempts to build only coal- and ash-handling equipment for boiler and gas houses. To secure the most efficient plant it is often necessary to combine the wares of several manufacturers, but to successfully accomplish the desired result it is essential that the builder shall know

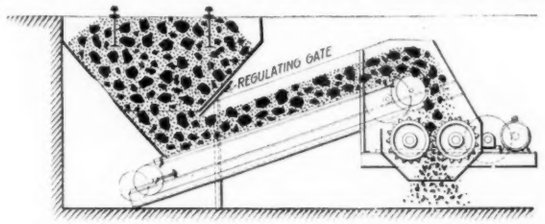


FIG. 2. ELEVATING COAL TO THE CRUSHER

thoroughly the uses and limitations of every standard device on the market. The result one is striving for is not necessarily the lowest first cost, but the proper balancing of the four factors—operation, maintenance, investment and adaptability.

There are two general ways of applying coal- and ash-handling equipment to a plant, one being to use one device for conveying both the coal and ashes, the other by providing separate machines for each duty.

The latter method is commonly referred to as the divorced system and is in use in nearly all the large Eastern power plants. The handling of ashes is usually considered as the severest duty that any conveyor may perform. The machinery must resist the destructive effect of the ashes in the chain joints, which cause rapid deterioration, and resist the distortion produced by hot ashes. Granting that the machine must be extra heavy and expensive to accomplish this result, it is unwise to use it for handling the coal, for although the ashes handled comprise but one-eighth to one-tenth of the total volume conveyed, the destructive action of the grit in the joints is in effect as long as the machine is in operation. For this reason chiefly the large stations years ago made the coal-handling machinery independent of that for handling ashes. When independent, one does not interfere with the operation of the other.

Let us assume the ideal condition of boiler-house location—that is, with the railroad track paralleling either the side or the end of the boiler house—and divide our study into three parts, as follows: (1) Unloading and crushing the coal; (2) elevating the coal vertically; (3) conveying the coal horizontally.

With the railroad track on the ground, a receiving hopper must be provided. One 10 ft. wide by 12 ft. long will be sufficient to receive the discharge from

both doors of a standard 50-ton gondola. The outlet to this hopper is usually fitted with a reciprocating feeder which delivers to a double-roll crusher. The arrangement of this group is shown in Fig. 1.

Sometimes it is necessary or desirable to elevate the coal while feeding it to the crusher, when an apron feeder, Fig. 2, must be used. This arrangement is from two to three times as expensive as a reciprocating feeder, principally because the apron feeder should not be inclined more than 22½ deg., although the writer has seen one or two operating at 30 deg. This makes it a very expensive elevating device, and therefore it should not be used unless unavoidable.

Part 2 contains few machines to discuss. The leading devices used to directly elevate coal at boiler houses are all chain-and-bucket machines, varying in construction according to the use to which they are put. The oldest coal elevator consists simply of a single strand of short-pitch chain, having malleable-iron or steel buckets of cup-like form attached to it at suitable intervals, the size and spacing depending on the capacity desired, except that when they are too close, they will not dredge the coal properly. The discharge is effected by the speed at which the elevator runs, the centrifugal effect causing the material to leave the bucket. This machine is shown by Fig. 3. It is not used for first-class work or where the material is elevated very high, but for small capacities, 20 to 25 tons per hour, and where the conveyor does not work more than a few hours a day, it is economical and is to be recommended.

A far better type of machine for elevating the coal is the V-bucket elevator conveyor, Fig. 4. As built by Beaumont, it consists of two strands of steel chain with steel V-shaped buckets spaced at frequent intervals between the chains, the discharge being effected by gravity. To do this, it is necessary to change the path from the vertical to the horizontal, the usual methods of accomplishing this being shown diagrammatically in Fig. 4. The numerous paths through which this machine may operate, permit of its use in varied ways. Diagram *A* is the most common path, the horizontal run either extending for the full length of the bunker, if it is not too great, or arranging it to discharge into a scraper or belt conveyor immediately upon its assuming the horizontal path, as at *C*. The arrangement shown at *B* is often seen where this machine is handling coal for ground storage, the upper horizontal run discharging to a pile on the ground, while the lower run operates in a tunnel under the pile and reclaims the coal. This system was applied at the boiler house of the American Railways Co., Dayton, O., as shown by Fig. 5. Here, the V-bucket elevator conveyor serves both the boiler house and the ground storage, by adding the horizontal run of path *A* to path *B*. A cross-feeder is used to deliver the coal from the railroad cars to the lower run of the conveyor, first passing it through a double-roll crusher.

While the V-bucket elevator conveyor is undoubtedly the best elevating medium to use, it can be skimped, like any other good conveyor, until it is so cheaply built that good service is impossible. The chains are its "backbone," and these must be of steel for several reasons. If malleable-iron chains are used (as they sometimes are), the elevator will be subject to disastrous wrecks, for a casting is a casting and is liable to fail through various flaws to which castings are subject. A casting in tension is not the best thing in the world to depend upon. The connection of the bucket to malleable chains makes a weak point, for the connection holes are but a scant few inches apart and the buckets are liable to twist off when dredging the coal out of the feeding boot. Steel roller chains are not subject to any of these faults. Neither are the bucket connections weak, for they are attached to the pins at the chain joints. These pins should be large in diameter, say ⅞ in., and of 0.30 to 0.40 carbon steel. They should be unbushed and not attached to the chain side bars; the pin is then a floating pin, free to turn easily, thus distributing the wear over the entire surface. Cast-iron rollers are used at each chain joint, these coming into play on the horizontal runs and at turns in direction, where they are engaged by the sprocket wheels.

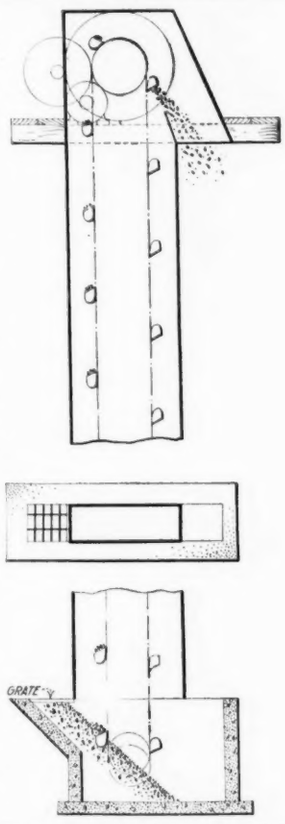


FIG. 3. SIMPLE BUCKET CONVEYOR FOR LIFTS UP TO 40 FEET

The buckets may be made of No. 10 plate as the coal does not wear them rapidly.

The trough is rectangular in cross-section, usually constructed of steel, with angle sides and a bottom plate at least $\frac{3}{16}$ in. thick. The upper flanges of the angles should have renewable wearing strips ¼ in. thick, for the roller chains to travel on.

The vertical runs are usually inclosed in steel-plate casings, No. 12 gage, and having corner angles to stiffen, besides connecting the plates. Sometimes the plates are flanged, but if this is done, look with suspicion on the rest of the equipment.

The capacity of a V-bucket elevator conveyor can easily be determined by simple arithmetic, but to avoid going through all these figures a good, conservative rule is: The cubic contents of the bucket in inches (water capacity) divided by 12 gives the tons (2000 lb.) per hour for a speed of 100 ft. per minute, the buckets being 12 in. apart. Other speeds and spacings are easily determined from this.

All sprocket wheels should have at least eight teeth, and shafts should be designed for both torsion and bending, allowing a working unit stress of not over 11,000 pounds.

A modification of the V-bucket machine is the continuous bucket elevator, which will operate in a vertical path and discharge directly over the head wheel, thus obviating the necessity of running horizontally to effect a discharge. This machine will also operate on an incline at any angle between about 45 deg. and the vertical. When discharging from the vertical position each bucket utilizes the back of the bucket in advance, as a chute, to deflect the material to the permanent

chute delivering to the conveyor. Fig. 6 shows this machine in detail. The remarks concerning the V-bucket apply to this machine also, except, of course, there is no trough to convey horizontally. The last two machines are without doubt the best elevating mediums to use, regardless of to what they deliver.

The centrifugal discharge elevator should not be used except for small lifts at low capacity and where the machine does not work often.

Conveyors may be divided into two general classes—flight conveyors, and belt or pan conveyors. The first class is by far the commonest and is further divided into four types—the single-strand chain-scraper flight conveyor, the single-strand roller-flight conveyor, the strand roller-flight conveyor, in which the chain and flights are supported above the trough by cross-spindles and rollers which travel on the channel sides of the trough. These rollers reduce the friction and the noise made by the scraper conveyor and such conveyors have greater capacity. The scraper-flight conveyor has malleable-iron flights with beveled corners to carry them over the gate openings in the trough and uses a single strand of malleable-iron chain.

The roller-flight conveyor uses a much stronger and more reliable steel chain and has steel-plate flights. The scraper flight is usually 5 in. deep and either 12 or 15 in. wide, depending on capacity, while the roller type of conveyor has flights 8 in. deep by 16 in. wide

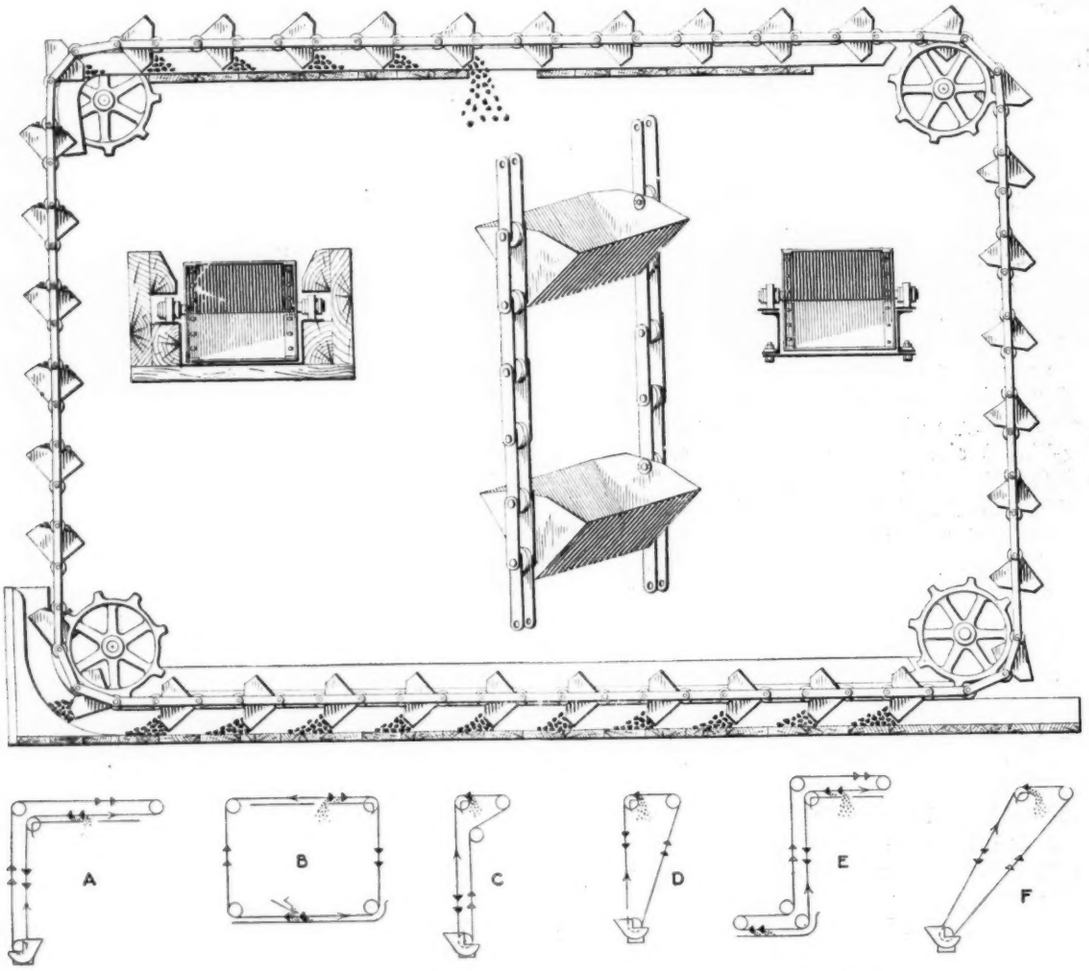


FIG. 4. V-BUCKET CONVEYOR AND ITS APPLICATIONS

double-strand roller-flight conveyor, and the screw conveyor. Figs. 7, 8 and 9 show the first three in the order named. The scraper-flight conveyor is much used for handling anthracite coal in retail yards, where breakage is a serious factor It does not cause breakage because it is slow-moving and discharges easily through openings in the trough and also because the flight scrapes directly on the trough plate, avoiding the grinding of coal between the flight and the trough, which would happen with any of the other three types. It has been much used in boiler-house work on account of its simplicity and low cost, but it has lately been superseded on first-class work by the single-

as a minimum, with 10 x 20-in. and 10 x 24-in. flights for greater capacities. Flights wider than this should not be used on a single-strand chain, for they will wobble.

Neither of the foregoing conveyors will handle run-of-mine coal, owing to the impossibility of getting the large lumps in the trough, which is obstructed by the chain in the center. For this reason the double-strand chain-roller flight conveyor is used for this purpose, and also when the conveyor is so long or so large that two chains are necessary to properly take the stress. Flights over 24 in. wide should have two chains, as already mentioned.

A double strand of chain is used when it becomes necessary to bend the conveyor from an inclined run to a horizontal one, making a "hump." With a single-strand roller-flight conveyor, the stress imparted to the cross-spindles by the chain would probably bend them, although under small stress the resulting bending movement on the cross-spindle would be almost negligible. A scraper conveyor, where the flights scrape directly on the trough, could not be used this way, but would have to be broken, the conveyor on the incline discharging the coal into the horizontal conveyor.

Screw Conveyor Unsuited to Coal

Troughs for these conveyors should be at least $\frac{3}{16}$ in. thick and should be bolted to the supporting channels to facilitate renewals. The remarks concerning chains, sprockets and shafts, previously made, apply here. The fourth type, the screw, mentioned for the sake of completeness, is not much used for conveying coal, being mostly used for grain and cement. The usual application to a boiler house is where pulverized coal is used. They consist of a blade wound spirally around a central shaft, the whole revolving in a U-shaped trough. The frictional losses are so large and the danger of breaks due to foreign material jamming at the shaft hangers are their bad features. They are very cheap, however, and this perhaps is the reason they are seen in boiler houses.

As to the second main class of conveyors, belts and pan arrangements, the former is by far the most popular; the latter can, in fact, be dismissed from coal handling at boiler houses, except for short feeders carrying run-of-mine coal to the crusher.

As a conveyor, it has two difficulties, one being the high cost and the other the impossibility of securing a discharge, except over the end of the conveyor.

The rubber belt has three advantages, but only two apply to boiler-house outfits. The first is lower power consumption and the second quietness of operation.

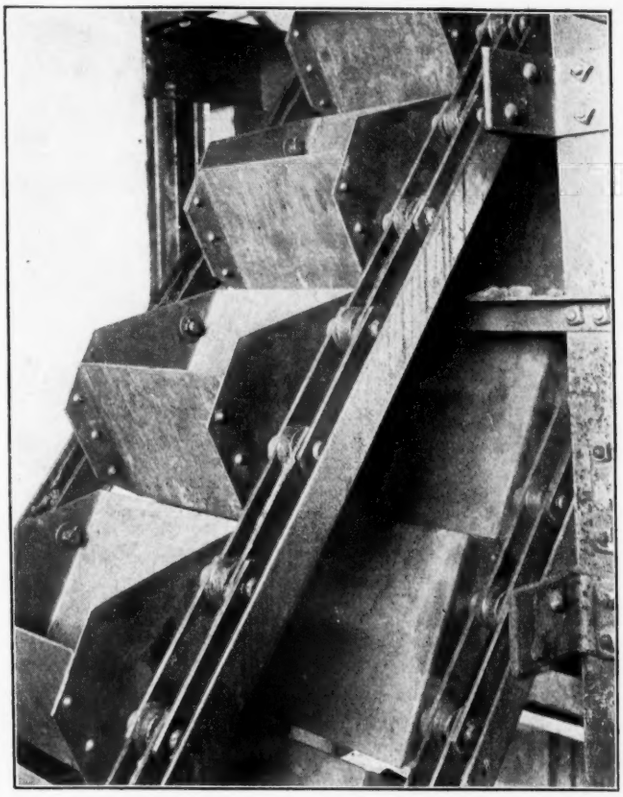


FIG. 6. CONTINUOUS BUCKET ELEVATOR

The third is that they convey materials 1000 ft. or more, while scraper conveyors are limited by good practice to about 300 ft. Manifestly the length of the average boiler house does not exceed the maximum length of the flight conveyor.

A belt-conveyor installation has several disadvantages which perhaps outweigh the few advantages. It is not easy to load and requires a ponderous device to

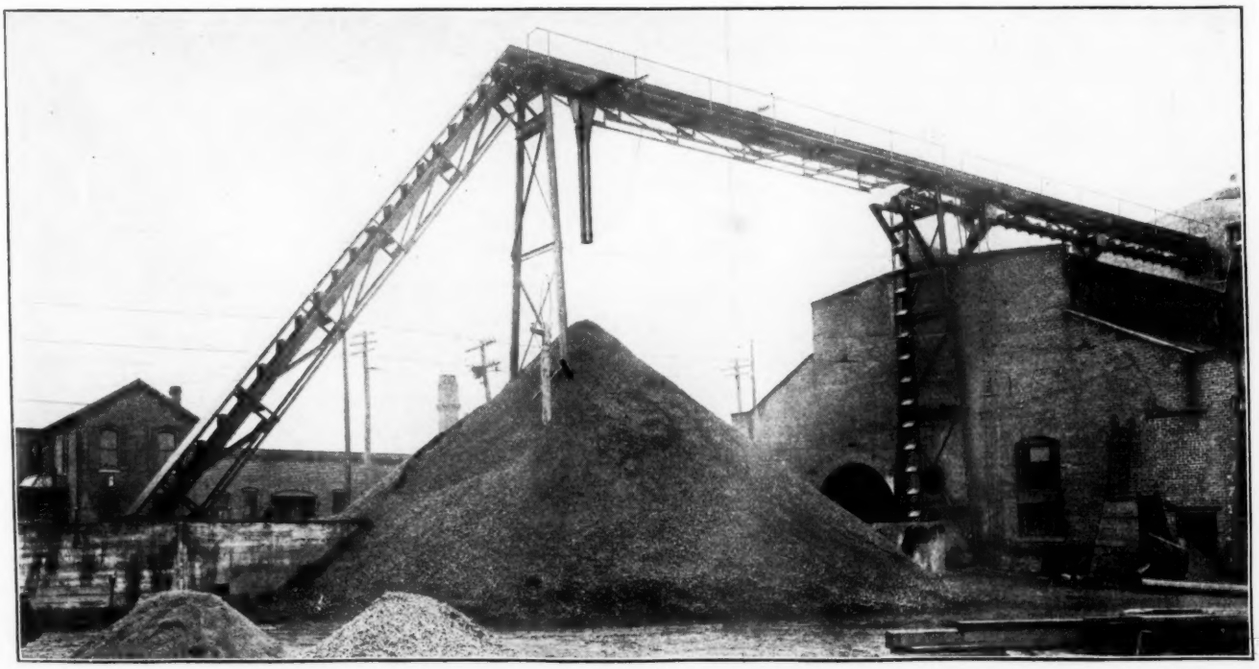


FIG. 5. BUCKET CONVEYOR AT THE AMERICAN RAILWAYS CO., DAYTON, OHIO

effect a discharge. It is hard to load because of the difficulty of delivering the coal to the belt at the same speed and in the same direction as the belt is running. This requires side guard plates extending along the

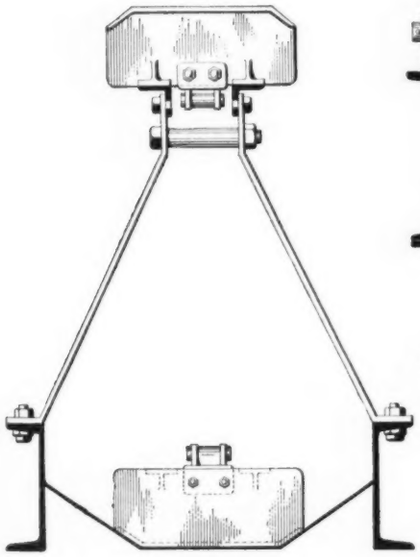


FIG. 7

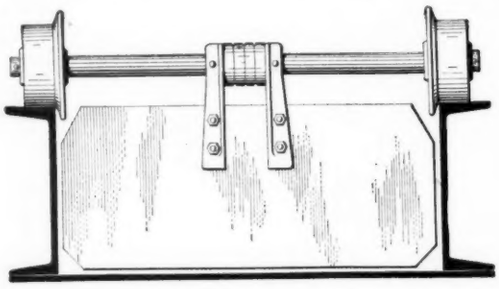


FIG. 8

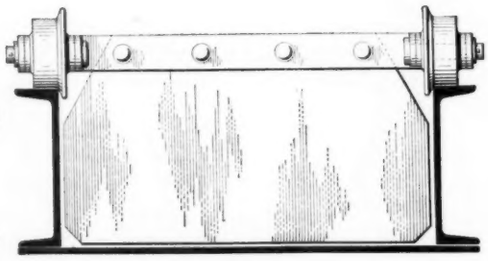


FIG. 9

FIGS. 7 TO 9. TYPES OF SCRAPERS FOR FLIGHT CONVEYORS
Fig. 7—Thick edge flight. Fig. 8—Square-corner roller flight. Fig. 9—Double-strand roller flight

length of the belt for a distance of four or five feet, as the difference between the speed of the coal and the belt at the point of impact causes a great deal of splashing. This loading condition is aggravated by the necessity of depressing the end of the belt conveyor, until it operates on an angle of 18 to 20 deg. This is due to the belt tripper, for when this device is at the loading end of the conveyor, the belt would rise directly from the end pulley if the belt was not depressed, and would be cut to pieces by the previously mentioned side guards. This is avoided by depressing the belt, but the danger of the guards sagging and cutting the belt is always present.

Should the belt be ruined suddenly in this manner, it means a long wait until a new one can be secured, for it is expensive to keep a new belt in stock and even then run the chance that it will harden before it is needed.

Wear on Rubber Belts

Belt conveyors require more attention than flight conveyors. The idlers are rather delicate mechanisms and require constant attention, otherwise they will not turn and the belt simply scrubs over them, wearing it out and consuming more power. Also, when the run is short, they wear out quickly, the wear being due to the impact of the coal on the belt at the loading point. It is obvious that in a conveyor twice the length the impact is distributed over twice the belt area of the shorter one for a given quantity of coal handled. Remember that a flight conveyor can be wrecked badly and put in service again by a local blacksmith, but a belt conveyor is dependent on the factory for repairs.

A typical belt conveyor installation is shown by Fig. 10, this being a view over the coal bunker at the boiler house of the Norton Co.,[2] Worcester, Mass. As to the first cost of the belt conveyor compared with the flight type, this varies according to the length. A belt conveyor without the tripper is more costly than the bevel-scraper flight type but cheaper than the roller types, but when the tripper is added (it is necessary) the belt is the most expensive one to use. If the length of the short conveyor is doubled, the cost is not, for one does not need another expensive tripper and then the belt is cheaper than the flight conveyor, but only slightly.

It is always well to bear in mind that low first cost often means high maintenance charges, as pointed out previously. The wear and tear on coal and ash conveyors is especially severe, and care in their selection is paramount.

[2]John A. Stevens, engineer; R. H. Beaumont Co., contractors for coal-handling machinery.

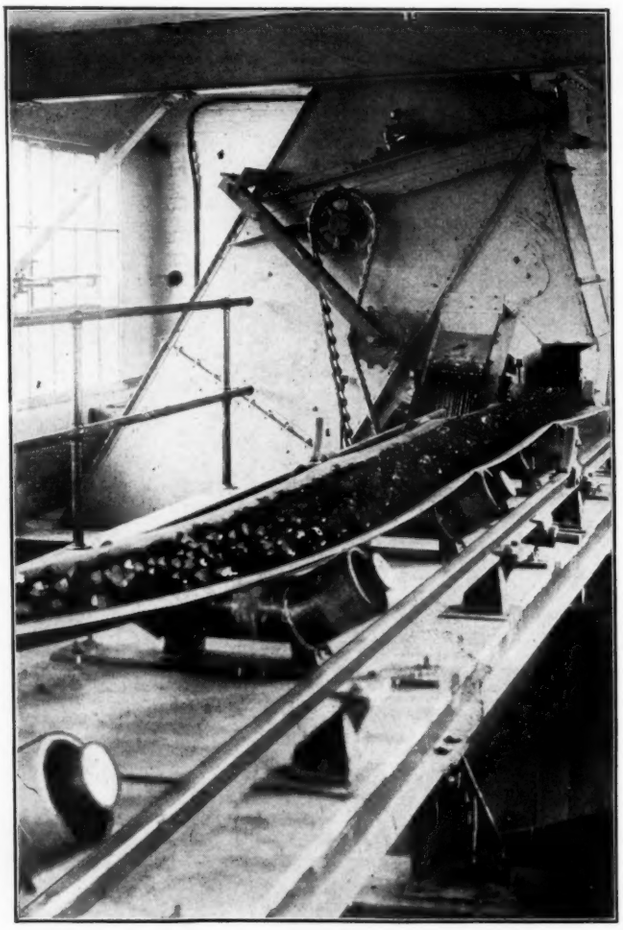


FIG. 10—BELT CONVEYOR, NORTON CO., WORCESTER, MASS.

The Electrical Study Course—Direct-Current Armature Construction

The development of the direct-current armature core is briefly described, and some of the defects in the earlier types are pointed out.

DIRECT-CURRENT armatures may be classed under two general types—ring and drum. Both types get their name from the shape of the core. The core of the ring type consists of an iron ring about which the coils are wound, as shown in section in Fig. 1. In the earlier type of machines the ring-armature

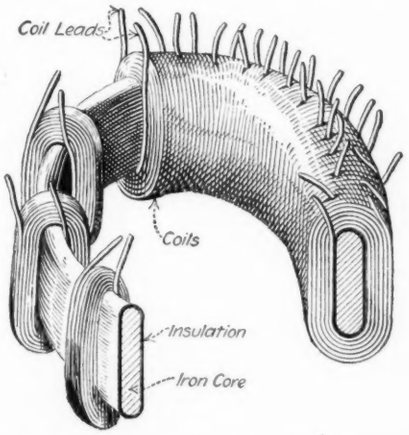


FIG. 1. SECTION THROUGH RING ARMATURE

construction was used to considerable extent, but it has since been practically abandoned. Some of the objections to this type of construction are that only one side of the coil is effective in generating voltage. Why this is so is explained in Fig. 2, where a ring armature is shown between the poles of a two-pole frame. It will be seen that all the lines of force are only cut by the conductors on the outer surface of the core. Therefore, only these parts of the coils are effective in generating voltage.

There is always a leak across the space in the center of the ring; that is, a small percentage of the lines of force, instead of flowing around through the core, take the path across the space in the center of the ring, as indicated in Fig. 2. The conductors on the inside of the ring cut the lines of force that leak across from one side of the ring to the other, in the same direction as the conductors on the outside of the core. Consequently, a voltage will be induced, in the same direction, in the side of the coil on the inner periphery of the ring, as in that on the outer.

In Fig. 2, consider the ring revolving in the direction of the curved arrow; then under the N pole the voltage in both sides of the coils is up through the plane of the paper, and under the S pole it is away from the reader. In either case it is evident that the voltages generated in the conductors on the outside and inside of the ring oppose each other. Since only a small percentage of the flux leaks across the ring, only this percentage will be cut by the conductors on the inner periphery, and the voltage generated in these conductors will be only a small percentage of that in the outside, the difference between the two being the effective voltage in the coil. The foregoing is another objection to the use of a ring armature.

Another difficulty is in winding the coils on the core, they have to be wound in place by hand. On account of having to thread the coils through the center of the core, the placing of the winding is a somewhat long and tedious job. These and other structural and electrical defects have caused this type of construction to be practically abandoned in favor of the drum type of armature.

The core of the early types of drum armatures consisted of a cast-iron cylinder keyed on a shaft, as in Fig. 3. Pieces of fiber were placed in small slots in the corner of the core, as shown, to facilitate the spacing of the coils around the periphery. One of the serious objections to the use of solid cast-iron cores was that they had heavy current generated in them, which not only greatly increased the temperature for a given load, but also loaded up the machine.

The foregoing will be understood by considering Fig. 4, which shows an iron core between the N and S poles of a magnet. If the cylinder is revolved in the direction of the curved arrow, then the side of the core under the N pole will be cutting lines of force in a right-hand direction and will have a voltage induced in it that

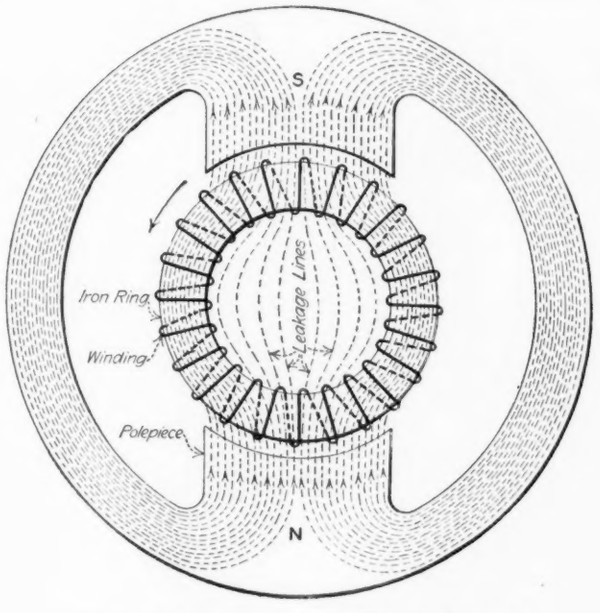


FIG. 2. MAGNET FLUX IN RING ARMATURE

will tend to cause a current to flow toward the reader. On the other hand, the side of the cylinder under the S pole is cutting the flux entering the pole in a left-hand direction, and consequently has a voltage induced in it that will tend to cause current to flow away from the reader. This is just what we found out about a loop of wire revolved between the poles of a magnet in the last lesson.

The condition in Fig. 4 is such that the voltage generated in one side of the core is assisting that in the other side. Consequently, a current will flow around in the core, as indicated by the dotted loop and arrowheads. This current is entirely independent of the winding on the armature and external circuit, and just as long as the field poles are excited and the armature revolved, a current will circulate or eddy around in the core. Since these currents circulate or eddy around in the core as water in a whirlpool, they are called eddy currents.

These eddy currents represent a distinct loss, not only in capacity, but also in the power used to drive the generator or motor. Eddy currents increase the temperature of the machine, consequently reduce the useful temperature range. For example, if the normal no-load temperature of the armature, if eddy currents did not exist, is 80 deg. F., and the maximum temperature that the machine can be operated at is 212 deg. F., then the machine can be loaded to the extent that would increase the temperature from 80 to 212 deg. F., or 132 deg. But on the other hand, suppose that the no-load temperature of the armature, due to eddy currents, is increased to 100 deg. F.; then the machine is only capable of carrying a useful load that will increase the temperature from 100 to 212 deg. F., or 112 deg. Consequently, the useful capacity of the machine under the latter conditions will be reduced.

It should be kept in mind that the amount of load that can be carried by any electrical machine is limited by the heating effect of the load. For a machine insulated with fibrous material this temperature must be limited to about 212 deg. F.

Another effect of eddy currents in the armature is to increase the power necessary to drive the machine. This will be understood by referring to Fig. 4. Here the generated current due to the core revolving, in the direction indicated by the curved arrow, in the magnetic field is indicated by the dotted loop and arrowhead in the core. Current flowing in the magnetic field will cause a pull to be exerted upon the core, just as explained for a single conductor carrying a current in a magnetic field in the lesson in the Dec. 4 issue.

The direction of the pull on the core may be determined by the rule for the direction of a motor, or, in Fig. 4, it will be found that the eddy currents in the core will produce a pull against the direction of rotation.

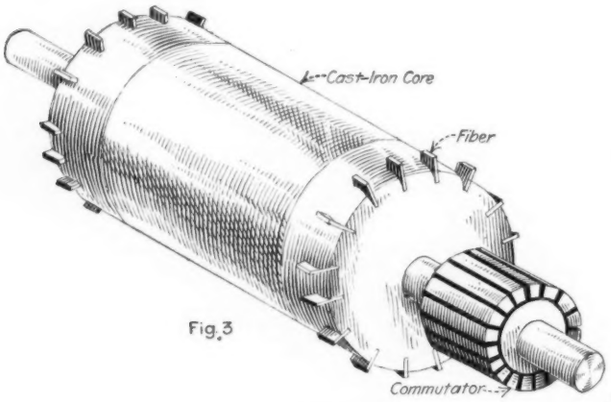


Fig. 3

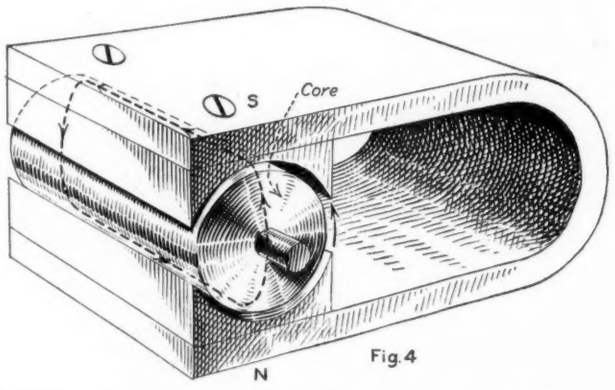


Fig. 4

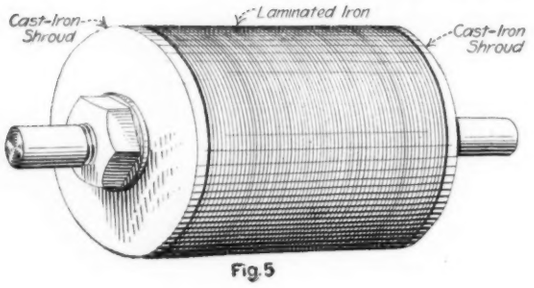


Fig. 5

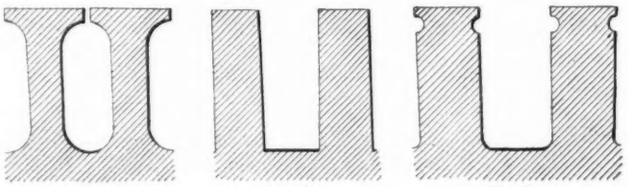


Fig. 7 Fig. 8 Fig. 9

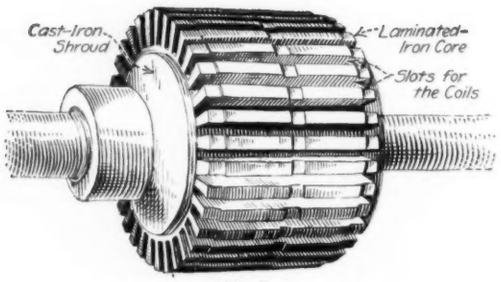


Fig. 6

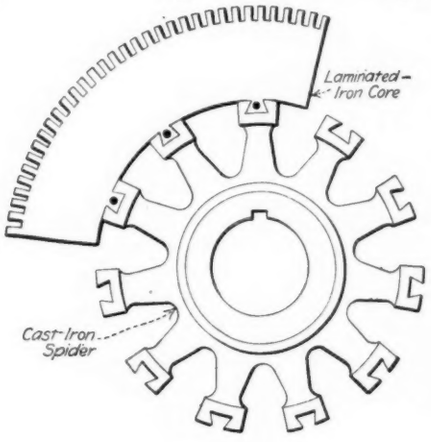


Fig. 10

FIGS. 3 TO 10. DIFFERENT TYPES OF DRUM-ARMATURE CONSTRUCTION

In other words, we assume that the core is revolving in the direction of the curved arrow, but the direction of the eddy currents in the armature core produces a pull in the opposite direction. Consequently, the source from which the armature is driven will have to develop power enough not only to drive the armature to supply its useful load, but also to overcome the effect of the eddy currents in the core.

Eliminating Eddy Currents

From what we have just seen, it is apparent that, if possible, these eddy currents should be eliminated. This is done to a very large degree by building up the armature core of thin sheets of soft iron or steel, as in Fig. 5. These sheets are from 0.01 to 0.03 in. in thickness. In the early type of machines the oxide on the surface of the sheets was very largely depended on to insulate one from the other. Although this did not completely insulate the disks from each other, it offered considerable resistance to the flow of the current in the core parallel with the shaft. In the modern machines the iron sheets that the core is made of are given a very thin coat of insulating varnish on one side, which practically entirely eliminates the effect of eddy current.

On account of the insulation the core has to be made slightly longer than a solid core would be, in order to get in the same volume of metal. Armature cores that are built up of thin sheets of iron are said to be laminated, and the sheets are frequently referred to as the laminæ. The cores of small-sized armatures are keyed to the shaft and held between cast-iron shrouds, or retaining plates, which are held in place by a nut threaded on the shaft, as in Fig. 5, or by bolts run through the core.

Objection to Smooth-Core Armatures

With these smooth-core armatures, the winding had to be placed on the surface of the core. There were several objections to this, such as the coils, being on the surface of the core, were exposed to mechanical injury; sufficient space must be allowed between the armature core and polepieces for the winding. On account of the comparatively long space between the armature core and polepieces, considerably more power is required to be expended in the field coils to cause the line of force to flow from the latter to the former, or vice versa, than if the core was as near the field poles as would be consistent with good mechanical construction.

Another serious objection is that the coils are wound on the core by hand, one coil at a time. Consequently, the coils can only be removed the reverse of the way they are put on. Therefore, if two or three coils are injured in the winding, it generally means that the whole winding must be removed and a new one put in its place, whereas, if the coils are made up separately, as in modern machines, the injured coils can generally be removed and replaced by new ones, by removing only a small part of the total winding.

All the difficulties cited are practically eliminated by slotting the core as in Fig. 6. The core is built up of thin sheets as in Fig. 5, but instead of the outer periphery of the disk being smooth as in Fig. 5, it has slots cut in it. These slots take different forms, some of which are shown in Figs. 7 to 9. However, when the coils are made up and insulated before they are put on the core, the slots in the core must be open at the top, as in Fig. 8 or 9. Where the coils are made up separately and insulated before placing on the armature, it is evident that the winding is not only more easily put in place, but can be better insulated.

The placing of the coils in slots in the armature core protects them from mechanical injury in case the bearings wear and allows the armature to rub on the polepieces; it also allows the space between the core and the field poles to be reduced to a minimum consistent with good mechanical construction. Consequently, the magnetic field is set up with a minimum power expenditure in the field coils. In the larger-sized armatures a cast-iron spider, as it is called, is keyed to the shaft and the laminated core built upon the spider, as in Fig. 10.

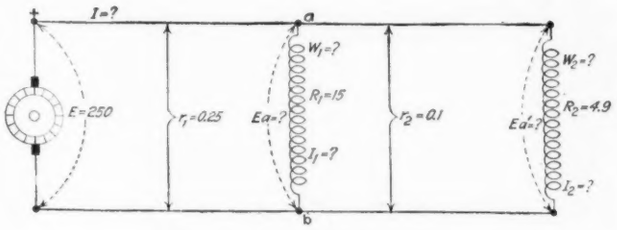


FIG. 11. COMPLEX CIRCUIT

The layout of the study problem is given in Fig. 11. The resistance from a at R_1 around through R_2 to b at R_1 is $R'' = r_2 + R_2 = 0.1 + 4.9 = 5$ ohms. This resistance of 5 ohms is in parallel with $R_1 = 15$ ohms, and the joint resistance of R'' and R_1 is

$$R' = \frac{1}{\frac{1}{R''} + \frac{1}{R_1}} = \frac{1}{\frac{1}{5} + \frac{1}{15}} = \frac{1}{\frac{3+1}{15}} = \frac{15}{4} = 3.75 \text{ ohms}$$

The total resistance of the circuit is $R = r_1 + R' = 0.25 + 3.75 = 4$ ohms. Then $I = \frac{E}{R} = \frac{250}{4} = 62.5$ amperes. To cause a current I to flow from the armature through the resistance of the two conductors r_1 will require a voltage $E_d = r_1 I = 0.25 \times 62.5 = 15.625$. Therefore, only a voltage $E_a = E - E_d = 250 - 15.625 = 234.375$ volts is available at R_1 to cause a current to flow through the circuit. The current that will flow through R_1 is $I_1 = \frac{E_a}{R_1} = \frac{234.375}{15} = 15.625$ amperes, leaving a current of $I_2 = I - I_1 = 62.5 - 15.625 = 46.875$ amperes flowing through R_2. To cause a current $= I_2$ to flow through the connecting wires between R_1 and R_2 will require a voltage of $E_d = r_2 I_2 = 0.1 \times 46.875 = 4.6875$. Hence, $E'_a = E_a - E_d = 234.375 - 4.6875 = 229.6875$ volts. The current flowing through R_2 is also $I_2 = \frac{E'_a}{R_2} = \frac{229.6875}{4.9} = 46.875$ amperes, which checks with the other calculation, showing that the work is correct. The total watts $W = EI = 250 \times 62.5 = 15{,}625$; total kilowatts $= \frac{W}{1000} = \frac{15{,}625}{1000} = 15.625$; and the total electrical horsepower $= \frac{W}{746} = \frac{15{,}625}{746} = 20.9$ horsepower.

A load consisting of 37.5 hp. of motors, allow 3.8 amperes per horsepower, and sixty-four 75-watt lamps is supplied over a two-wire feeder, 475 ft. long. If the

voltage is 240 at the source, what size will the conductors have to be to maintain 235 volts at the load end of the feeder when transmitting the total load? If the load is used on an average of 6.5 hours per day for 26 days, find the cost of power at 7.5c. for the first 800 kw.-hr., 6c. per kw.-hr. for the next 1000 kw.hr. and 4.5c. for the remaining kw-hr. consumption. The kilowatt-hour meter is located at the load end of the feeder.

Testing for Ammonia in Brine

Leaks in coils carrying ammonia and surrounded by brine or water are difficult to detect and usually continue until the brine or water has the odor of ammonia. If one suspects that coils are leaking, a sample of the brine may be drawn into a test tube or other receptacle (glass preferred) and a few drops of Nessler's reagent added. If the brine contains a little ammonia, it will take on a yellow shade; if there is much, the brine will turn brown when the reagent is added.

Nessler's reagent may be made as follows: Dissolve 17 grams of mercuric chloride in 300 c.c. (approximately 10.6 oz.) of distilled water. Next dissolve 35 grams of potassium iodide in 100 c.c. (about 3.5 oz.) of distilled water. Add the potassium-iodide solution to the mercuric chloride and stir until a red precipitate is formed. Now add 120 grams of potassium hydrate dissolved in 200 c.c. (about 7 oz.) of water. As the solution will get hot when the potassium is added, it should be allowed to cool before being stirred. When cool, pour in distilled water until there is 1 liter (about 1 qt.) of solution. Next add more mercuric chloride until a permanent precipitate again forms.

The liquid should stand until the precipitate has settled and left the solution clear, after which pour it into a dark-brown or blue glass-stoppered bottle, and keep it in a dark place.

Handy Gate Lock

It is frequently advisable to prevent visitors to power plants from having free entrance to the operating floor. An engineer may be busily engaged on work that requires his undivided attention only to be interrupted

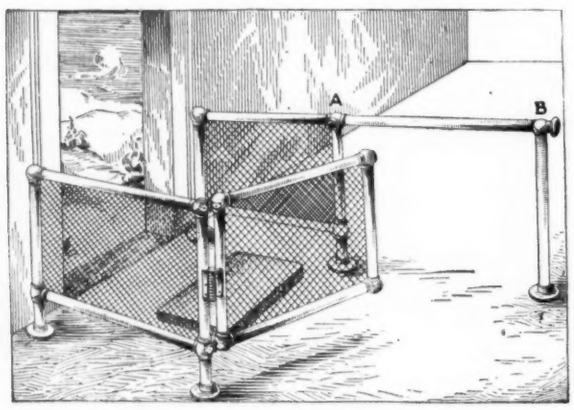


FIG. 1. LOCKING GATE FOR POWER PLANT

by the presence of some intruder who has wandered into the plant, there being nothing to prevent him from roaming at will about the premises. It does not cost much to erect a pipe railing covered with wire netting at the inside entrance of the plant, with a gate which is fastened by a lock that can be operated only by an attendant from the inside.

Such an arrangement is shown in the illustration. The locking point is at *A*, Fig. 1, and the lock can be operated only by turning the handwheel at the end of

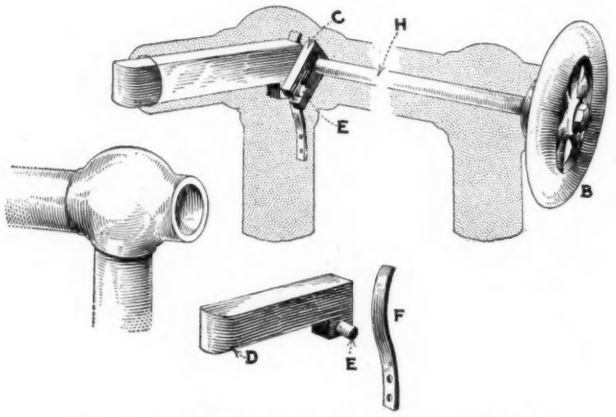


FIG. 2. DETAILS OF THE LOCKING DEVICE

extension *B*. Details of the locking device are shown in Fig. 2. The latch *D* slides in the pipe connection and the end enters an opening in the joint at the top of the gate frame. The bolt is fitted with a pin *E* and is kept in the locked position by the spring *F*. Engaging with the pin *E* is a slotted block *G*, which is secured to the rod *H* and is fitted with a handwheel *B*. When it is desired to admit passage through the gate, the handwheel *B* is turned toward the left; this will move the pin *D* from the gate and permit of its being opened.

Spring hinges are used on the gate, and after it has been opened it will spring shut and automatically lock, the bolt end acting the same as the catch on an ordinary house door, the end being made at an angle so as to slide over the end of the gate when it is closing.

The shortage of fuel of all kinds in Denmark has kept the large users of power anxiously looking toward Sweden for electric power, which at times they have in abundance. According to *Commerce Reports* the water power now developed in Sweden seems not to furnish any surplus power beyond the country's own needs during dry seasons, but during about half of the year there is generally a considerable exportable surplus. The villages in the northern part of Sjælland have been obtaining some small quantities of electricity by cable across the sound, and occasionally some of it has been used in Copenhagen. Now arrangements are being made to lay additional cables across the sound, with the intention of furnishing the street-car service of Copenhagen and Frederiksberg with a large amount of power. The difficulty in obtaining copper cables and electric transformers is delaying this work. It is expected that most of the power will come from the Laga Lakes and the Trollhättan Falls in Sweden.

Industries making war materials and supplies will of course get coal even if those producing luxuries get none. We have the paradox of the engineer engaged in war worrying less than he of the antique furniture factory.

Editorials

Chances for Promotion in Power Plants

IT IS no exaggeration to say that there never was a time in the history of power-plant service when the prospects of promotion were better than they are today. There are many reasons for this, but among the most important are the vital necessity power has become for war and peace tasks alike and the sure and sustained demand for low-cost energy which will be felt in many parts of the world after hostilities have ceased. To overlook present difficulties in power-plant operation would be a mistake; conditions are very trying with regard to fuel supply, prices of all materials and of labor in a great number of stations. In a number of cases central stations have taken over the service of independent plants, but it by no means follows that even a major share of these plants will always find purchased energy cheaper than their own production. Costs are rising in the central station itself, and it is a daring company indeed today which will make a new power contract without a coal clause in its heart which in a measure seeks to offset increasing fuel prices by additions to the unit energy rate, and vice versa.

The great majority of our productive industries must continue to function, war or no war. "Business must go on" is a true expression of the situation. The war, it is obvious, brings many changes to industry. No small number of engineers are serving their country at the front or in immediate preparation for active military or naval duty, but thousands upon thousands are quietly doing their bit at the old stand, working hard to overcome the handicaps the present supply prices and shortages impose and striving to prepare themselves for larger responsibilities. The duties of civil life must be performed, and the work behind the firing lines could not continue without the loyal service of the coal passer, the engineer, the switchboard operator, pumpman, repairer and all the rest of the staff upon which continuous and efficient production of high-class energy depends. Now the changes which the war brings carry into the industrial world in countless places and in unexpected ways. The war must be won, no matter what the cost to ourselves and our allies. Shifts from one plant to another take place; sometimes the engineer is obliged to lose his hold upon a most satisfactory position; but in the long run, in fact almost in the short run, things will work out to his interest if he makes the most of his opportunities. The world cannot lie back and simply refuse to take advantage of all skilled and highly trained men in the engineering field not called to direct military service; it must utilize such men to the full, even if a period of readjustment accompanies the change from one service or post to another.

This is a time when it is good to realize the vast amount of work which lies ahead of us all—not only now but during the reconstruction period to follow the war, for it is inconceivable that such a period will not come. The peculiar talents of the engineer will be in demand indefinitely, so far as we can see. Now is the time, then, to realize the sound fundamental conditions of the power-production industry as related to the allied world's economic needs, and to make personal devotion to the cause of world efficiency one's watchword. Specific opportunities for promotion may be out of present vision, but we are now in a great transition period and those opportunities are bound to come to him who is prepared to meet the new professional standards, or at least who holds the larger outlook and deeper training for the coming years.

Conservation of Fuel

THE Government has asked that every true American conserve as much as possible the fuel which is so necessary to the effective conduct of the war. It should be considered the patriotic duty of every engineer and fireman to see that the last elusive B.t.u. in the coal he burns, is harnessed and made to do its share of the work his plant is engaged in.

There is little doubt but that many seekers after personal gain will attempt to use this plea of the Government to further their own selfish interests.

We may expect a revival of ash-burning schemes and similar fakes, as well as a greater effort on the part of those who sell more legitimate apparatus, intended to economize fuel, to increase their sales.

While every device and improvement that will reduce coal consumption is exceptionally desirable at this time, production is hampered by lack of man-power, transportation is clogged, and the engineer should realize that the saving he can make without the outlay of money is the kind that counts most.

If your employer's money is spent without a very considerable return in the way of fuel saving, the ends of the Government are more certainly defeated than if no change was made. Every cent saved in the purchase of nonessentials and applied to the purchase of necessary things makes a balance of two cents on the right side of your plant account. This is the kind of saving that will do the Government, as well as the "Boss," the most good at this time. Such saving may be made by the proper use of the tools at hand. The common ways that fuel is wasted in the boiler room are by improper firing methods, dirty boilers and leaky settings and piping. These wasteful defects may all be corrected in the average plant without any considerable outlay in money. Generally, where two or more boilers are used, the failure to balance the draft properly between them is a serious source of waste.

It is a simple matter to see that the dampers are adjusted so that the proper amount of fuel is burned under each boiler to make it do its share of the work in accordance with its size. In connection with the efficient operation of boilers it should be remembered that while it is necessary that the boilers be kept clean

internally—and that this is also necessary from the standpoint of safety—the greatest returns in fuel saving are secured from the careful cleaning of the surfaces in contact with the gases. This is especially so with those surfaces in contact with gases of lower temperature, such as the tube surfaces in the horizontal-tubular boiler. Soot is liable to collect on such surfaces, and there are probably few substances that are better nonconductors of heat than soot. Clean the tubes out at least once every day and watch results at the coal pile. This is hard, dirty work, but you will derive satisfaction from the fact that you are performing a patriotic duty in saving fuel without an outlay of money, which counts at both ends. Tell the "Chief" of your patriotic ambition to save fuel in this time of need, and he will no doubt coöperate with you and see that you are given necessary assistance.

Must Efficient Management Be the Most Expensive?

IN A recent hearing before one of the public-utility commissions of New England the opponents of a rate increase urged that a more efficient and less expensive administration would solve many of the problems under consideration.

The relation between efficiency and cost of management is a question of much interest. It comes directly home to the operating executive of the power plant, and many an engineer knows that his employer's ideas on this subject are in need of revision.

In a nutshell, the issue raised is whether the cheapest service is the best. Translated into power-plant engineering, it is simply a question of getting service out of the station of lowest cost and out of the poorest-paid staff, and deluding oneself that the combination represents maximum efficiency. There are low-paid station organizations accomplishing wonders with equipment that represents anything but the most modern designs, it is true. There are also administrations that may well be looked upon as extravagant by the less fortunately circumstanced. Admit all this, and still the fact remains that A-1, first-class, top-notch service costs real money. Here is the point: That service is the best which costs least *per unit*, taking *all* the factors into account—not merely operating expenses, but fixed charges, and in addition to these, quality of output with respect to regularity and reliability.

Now, management is only one factor, though a most important one, in this total cost, in this minimum unit cost which represents the best performance of the investment and its personnel. In a narrow sense efficient management costs more than cheap administration; in the long run and in a broad sense it costs far less. It all comes down to "making good." If by paying higher salaries and wages the cost of production, taking all items into account, decreases per unit of output, there can be but one answer to the question at the head of this article, and that answer is "No." On the other hand, if the unit cost of output is found in a given case to be higher *in toto* with a poorly paid staff and correspondingly lower total payroll, the answer is: "Pay enough to secure and maintain an efficient administration; measure results not by total outlay but by cost per unit, and everyone will be better off." Maximum efficiency, of course, is costly, but if the conditions demand maximum efficiency or the nearest approach to it that can be realized, anything less may be utter extravagance, or money thrown away.

Giving Credence to Rumors

RUMORS are rife these days regarding mismanagement in this, that and the other thing, all of which are detrimental to the country as a whole regardless of whether they are true or not.

In the Eastern States the public recently indulged in excitement because of the rumor of a salt shortage, which does not exist. The real shortage of sugar, the cause of which is debatable, has given the rumormonger an opportunity to howl calamity and foster in a small measure discontent in the minds of many householders; the coal shortage has produced a state of mind in others bordering on a panic; and so it goes.

There will doubtless be other real and imaginary shortages that the American public will experience before the war is over, and it is about time that we began to realize that our manner of living must be changed to meet the conditions brought about by our country entering into war against Germany. What cannot be cured must be endured in this country, as it is in others that are not so well off as ourselves.

An American just returned from France, after serving with the French at the front, said that he had heard more grumbling over a little sugar shortage since returning to America than he had heard regarding conditions in general during his entire service in France. That the American people are gullible in some respects is well known, and they are prone to swallow almost anything that is put before them without waiting for the proof of the pudding.

For instance, public statements have been made to the effect that anthracite coal, of which there has been a real shortage in New York and other cities, has been delivered to the army cantonments in excessive supplies and that it is being wasted. As a result of these reports the Anthracite Operators' Committee has made an investigation through its secretary, E. W. Parker, who visited Camps Merritt, Dix and Upton, and his findings are given in a statement signed by F. W. Warringer, Chairman of the Operators' Committee, as follows:

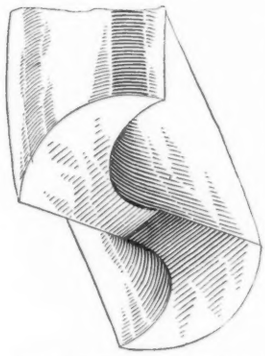
> Referring to reported waste of anthracite, Mr. Parker says that the quantity of coal wasted has been negligible, and where it has been scattered some distance from the car, care has been taken to gather it up and reshovel it into the piles.
>
> Mr. Parker reports that only on one occasion at any of the camps, and then owing to a washout on the spur track leading to the cantonment, was there any congestion in the delivery of anthracite or the return of empty cars. His judgment is that anthracite is being delivered at the cantonments in no greater amounts than is necessary nor faster than it should be to keep a safe forward supply, also that it is being received with regularity.

The probabilities are that many such rumors will, when investigated, prove to be without foundation, and all Americans should give scant attention to them, as they are doubtless started with a purpose on the part of someone who is interested in creating discontent in the minds of the people.

Correspondence

Drilling Metal by Hand Power

Occasions frequently arise in the course of an engineer's duties when holes must be drilled by hand for all sorts of purposes, from an air vent in a pipe or radiator to drilling out a broken stud. The job can often be finished with a breast drill or an ordinary bit brace before the conventional ratchet and "old man" equipment can be rigged up—and without any great physical effort. The one thing necessary is to drill a small hole first, followed with the large drill and if necessary with intermediate sizes until the finishing size can be operated easily. The philosophy of the thing is simply that the center or flat part of a drill cannot cut the metal; it only scrapes it off when great pressure is exerted to force it down and the larger the drill the wider this flat point is. Therefore if a hole is first drilled that is equal in diameter to the width of the "nose" of the larger drill, the pressure required to make the drill "bite" will be comparatively little. Try it and see.



END VIEW OF TWIST DRILL

Another advantage of drilling a small hole first is the fact that a drill cannot cut "oversize" when not ground evenly, as it otherwise will. As to the reason for choosing a brace against a geared breast drill, the latter is usually geared for speed and the drill cuttings are necessarily thin—mere scrapings—because the turning power is limited, but with a long-sweep brace the leverage is greater and heavier chips can be cut out. In other words, it takes more strength to remove the metal in pulverized form than in chips of reasonable size. In using a ratchet drill about one-third of the time and effort is lost on the return or non-cutting stroke. A geared drill—geared down—is a whole lot better because the full sweep is utilized. A small blacksmith drill press can often be utilized if bolted to a light timber of convenient length to block in place.

Frequently an old flat drill is considered good enough for use in a ratchet, while twist drills are cheap and so much better that they should be procured if possible—at least up to a reasonable size—and the flat drill used only for large or odd-sized jobs. J. LEWIS.

New York City.

Ammeters Were Reversed

Indicating ammeters and voltmeters of the permanent-magnet type will indicate the polarity of the voltage that is applied to them. This is because a reversal of the external polarity reverses the flux of the movable coil, but does not reverse that of the permanent magnet. Therefore a reversal of the polarity of the source reverses the throw of the needle for the same reason that interchanging the field or the armature connections of a direct-current motor reverses the direction of rotation of the armature. Meters of other than the foregoing type will not indicate the reversal of the polarity of the source to which they are connected, for such changes reverse the fluxes of both the controlling and the deflecting fields, leaving the polarity relations of the two fluxes the same as they were before the reversal, for the same reason that reversing the line connections of a d.c. motor does not affect its direction of rotation.

If a direct-current generator in normal operation has imposed upon it suddenly sufficient overload to greatly reduce the speed of its prime mover, the polarity of the generator may become reversed. The reason for the reversal is that at low speed and heavy current, the voltage on the shunt field is low, which decreases the flux from the field poles where the reaction of the heavy armature current is able to reverse the magnetism of the polepieces, before the circuit-breaker acts to relieve the situation.

An operator complained that the two ammeters used with two generators that were operated in parallel had reversed, although the voltmeter used for paralleling the machines had not. An inspector investigated and found that the voltmeter was of the separately excited type while the ammeters were of the permanent-magnet type; therefore what had happened was to be expected under the circumstances, which were as follows: A few days previous the generators had been subjected to an overload so heavy that the governors had tripped out the waterwheels driving the generators. It was then that the polarity of the generators had been reversed and for the reasons just given. As there was no objection to the reversed polarity, the ammeter leads were reversed on the instrument shunts in order to make the needles deflect in the proper direction.

Brooklyn, N. Y. E. C. PARHAM.

[Where the polarity of a direct-current generator is reversed when a heavy short-circuit occurs, it does not necessarily follow that the reversed polarity is due to armature reactance alone. When a generator slows down, which is supplying a motor load that has considerable inertia, the mechanical load drives the motors as dynamos, and they in turn supply a reversed current through the series-field windings of the generator, which in many cases is heavy enough to reverse the polarity of the latter.—Editor.]

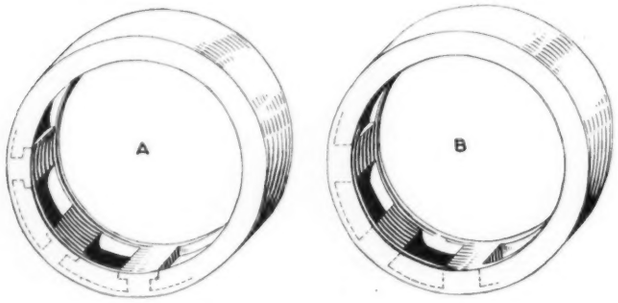
Publicity About Turbine Accidents

Referring to the article by C. H. Camp regarding turbine accidents, published in *Power* for Nov. 20, 1917, I wish to state that he has been misinformed about the Port Huron Electric Co. No such accident ever occurred to my knowledge, and I have been here for some time.

Port Huron, Mich. D. J. RICHARDS.

Poorly Designed Bull Ring

It was recently necessary to put a new bull ring in an engine, and when it arrived it was found to be made about as shown in the sketch *A*. The skeleton form was designed for lightness and was made with cross-bridges to support the keys and to strengthen and stiffen the ring. It will be seen that between the bridges pockets are formed which extend under the top of the bridge about ¾ in., thus making a receptacle for scale and core sand, which is difficult to remove. Although care was taken to clean out these pockets by means of chisel, scrapers, brushes and air blast, trouble



TWO DESIGNS OF BULL RINGS

developed soon after the engine was started, and upon the ring being removed, it was found that a small amount of grit had been loosened by the action of heat and cylinder oil, thus causing the cylinder to be badly cut and scored.

Had the ring been constructed as shown at *B*, all particles of sand or grit could have been scraped out easily and considerable time and expense saved. The ring would have been but little heavier, and it would have been easier to mold. CHARLES W. OAKLEY.

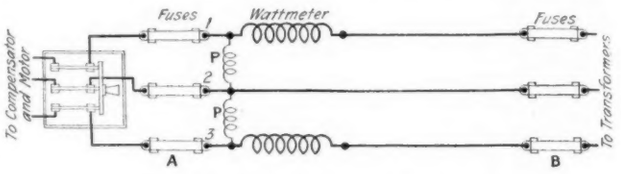
Passaic, N. J.

Lamp Test Indicated a Ground

Each of the three conductors of a three-phase three-wire service involves two of the phases of the circuit, and an open-circuit in any one of the three wires will interrupt two of the phases. With only one phase active, there will be no phase rotation, therefore a three-phase motor will be unable to start if connected to the circuit.

The figure shows the line circuit for a 220-volt three-phase motor, which was complained of because it could not be started. The two sets of fuses shown were active on both positions of the starting compensator. A test with a 220-volt lamp showed that the middle fuse located at the transformers about 200 ft. away from the motor, was blown. The test lamp would light when applied across lines 1 and 3, but would only glow dimly when applied to 1 and 2 or to 2 and 3. The motor trouble was a plain case of single-phase operation which was remedied by replacing the blown fuse. The fuses at *A* and *B* were all of 60-amp. capacity and a fuse was as liable to blow at *B*, which was inaccessible, as at *A*, which was immediately above the motor. In order to insure that the next fuse would blow in a convenient place, 45-amp. fuses were substituted for the 60-amp. fuses at *A*.

As pointed out in the foregoing, when testing for voltage the lamp showed an appreciable glow when held across conductors 1 and 2 or 2 and 3; this suggested the existence of a leak to ground. The operator spent some



THREE-PHASE-MOTOR LINE CIRCUIT

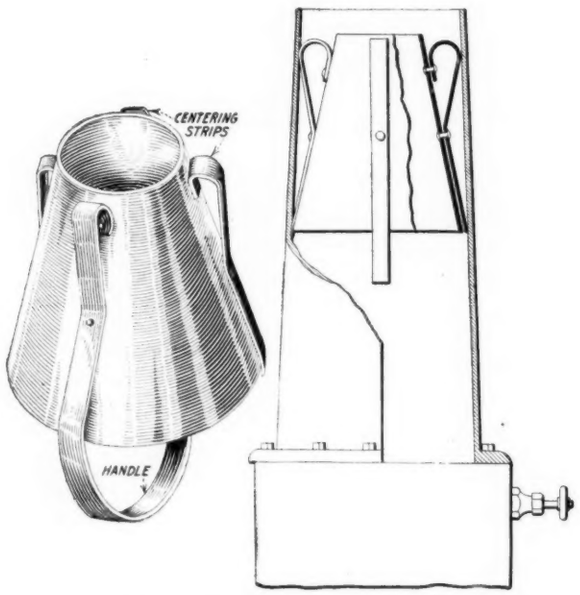
time in trying to locate a ground, when he happened to think of the watt-hour meter, the connections of the potential coils of which are indicated at *P*. On disconnecting the potential coils, all wires tested clear.

Brooklyn, N. Y. E. C. PARHAM.

Reducer for Gas Burners

In a boiler plant using natural gas as fuel it sometimes becomes necessary to turn the gas very low, often resulting in the gas firing back into the burners, or to run with one burner nearly full on, which is undesirable and likely to deposit sediment in a form that causes blistering or bagging. To overcome this I hit upon the idea of reducing the nozzle of the burners from 5 to 3 in. in the manner shown in the illustration.

No. 20 gage galvanized iron was used to form a funnel-shaped reducer to fit into the regular burner



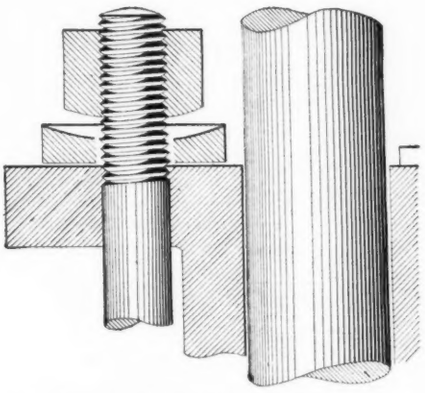
NOZZLE OF GAS BURNER REDUCED

with three or four strips ¾ in. wide riveted on in the manner shown, to center the small end. A handle is also provided to insert and remove the reducer. By using these reducers, it is possible to reduce the gas so that three burners can be kept going in place of one, giving a better distribution of heat and a more economical mixture than could be obtained with the large burner burning low without the reducer.

Calgary, Alta., Canada. W. H. DANCE.

Relieving Side Strain on Studs

To keep studs or gland bolts from breaking from side strain, I make a washer a loose fit over the bolt and flat on one side but concave on the other. The nut is then made convex to fit the hollow side of the washer, forming a ball joint. The washer will slide one way or the other and adjust itself to the pull so that the stud does not bend repeatedly and finally break. The illustration shows the shape of the nut and special washer as described.



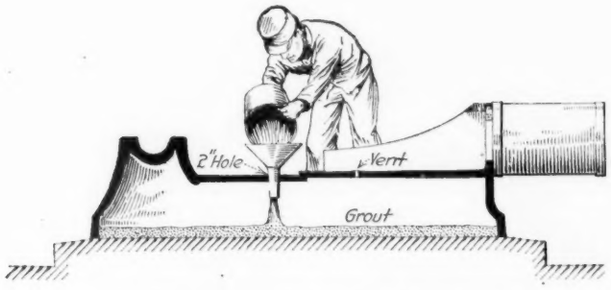
NUT AND WASHER FORM A BALL AND SOCKET JOINT

R. A. DAVIDSON.

Colton, Calif.

Grouting in an Engine Bedplate

Sometimes the hollow bedplates of machinery will move slightly on the foundation if insufficiently grouted, and cases of this kind are aggravating and difficult to correct. The usual cause is that the grout was not forced into all the interstices under the heavy casting, consequently there is not sufficient bearing surface. One way to correct such a defect is to drill a hole, about two inches diameter, in the top of the bed and another for an air vent and pour in grout enough to fill the inside of the bedplate to a depth of several inches. This will usually stop any motion of the frame on the foundation.



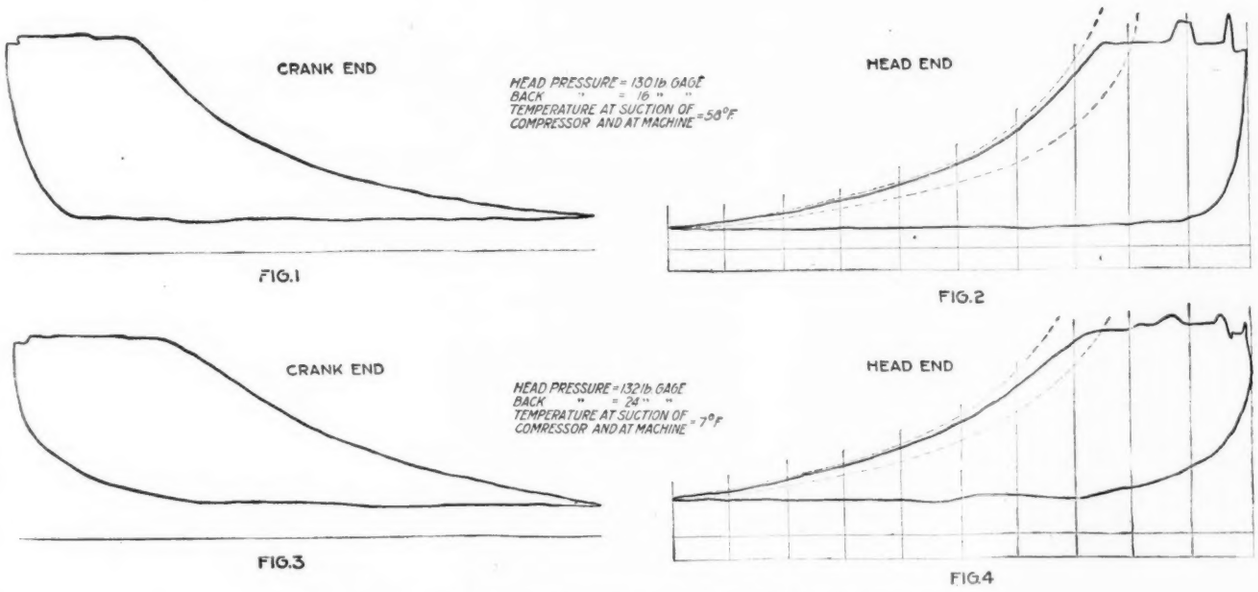
GROUT POURED INSIDE OF HOLLOW BEDPLATE

D. R. SHEARER.

Johnson City, Tenn.

Ammonia-Compressor Diagrams for Discussion

The indicator diagrams shown in Figs. 1 to 4 are from a 10-ton Wolf-Linde ammonia compressor, 9½ x 15 in., running at 80 r.p.m. normally, and motor-driven. I shall be pleased to have readers of *Power* discuss the diagrams.


CRANK END
HEAD PRESSURE = 130 lb GAGE
BACK " = 16 " "
TEMPERATURE AT SUCTION OF COMPRESSOR AND AT MACHINE = 58°F
HEAD END
FIG.1
FIG.2
CRANK END
HEAD PRESSURE = 132 lb GAGE
BACK " = 24 " "
TEMPERATURE AT SUCTION OF COMPRESSOR AND AT MACHINE = 7°F
HEAD END
FIG.3
FIG.4

FIGS. 1 TO 4. AMMONIA-COMPRESSOR DIAGRAMS FOR DISCUSSION

J. C. HARRISON.

El Campo, Tex.

Insufficient Protection Around Flywheel

In a station that I visited recently, there was an immense flywheel in motion just at the end of a runway, about six inches from the end of the walk, the floor being about level with the hub of the wheel. There was a single wooden handrail around it, nailed to the top of posts, leaving the whole space below unguarded.

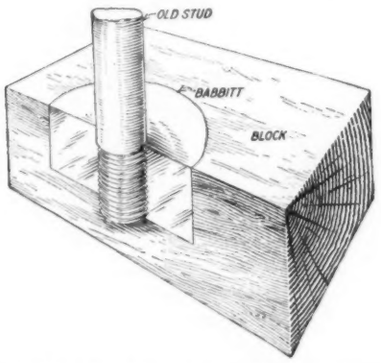
The engineer in charge said that one man had slipped

into this wheel, but no better protection had been placed there to prevent anyone else from meeting with a similar accident. Failure to improve conditions after one such accident seems like gross negligence.

Philadelphia, Penn. W. H. NOSTAN.

Babbitt Templet for Thread Size

Following is a shop kink that may be of interest to readers of *Power*. I recently bought a set of new ¾-in. studs for the water valves of a duplex pump, but the threads had not been cut deep enough to screw into



TEMPLET MADE BY POURING BABBITT AROUND OLD STUD

the seats properly and as they were special threads it was necessary to "chase" them in a lathe. The pump could not be spared from service long, and the question arose as to how we would know when they were "chased" to the proper depth. This was solved by boring a 1½-in. hole in a wood block to the depth of the threaded portion of the studs. The threaded portion of an old stud was then set in the hole in the block and melted babbitt poured around it. When it had cooled, the stud was backed out, leaving a templet of the thread in the metal, as shown in the illustration. The new threads, cut to fit this templet, fit perfectly in the valve seats.

Ithaca, N. Y. C. B. HUDSON.

Induction Motor Heated

When a three-phase induction motor of standard design has trouble that causes abnormal heating even when the motor apparently is operating without any connected load, the source of disturbance very likely will be unbalanced voltage, which may be determined by connecting a voltmeter across the different phases, or an ammeter is successively connected into the different supply wires. If under such conditions the readings prove to be balanced, the motor either is not what the nameplate calls for or the seat of trouble is elsewhere.

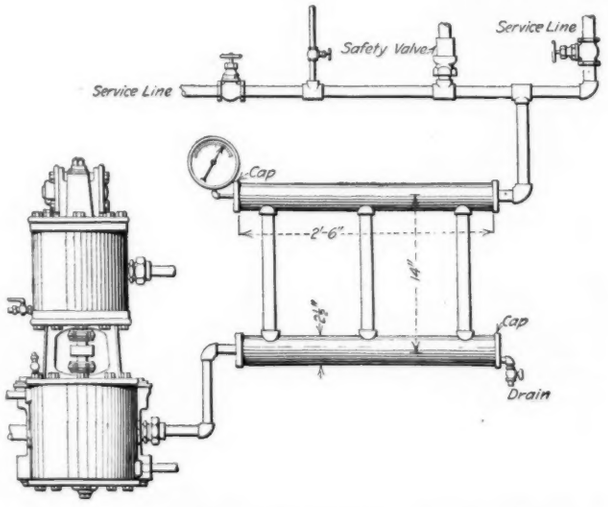
The operator of a motor-generator set which consisted of a three-phase induction motor coupled to a shunt-wound direct-current generator, complained that the motor got so hot as to smoke even when the generator was carrying no load. An inspector was sent to investigate and by means of an ammeter and a voltmeter determined that there was nothing the matter with the motor as far as the meter readings would indicate.

During the taking of the no-load readings of the motor, the generator was entirely disconnected electrically and therefore could not even excite its field poles. In order to determine whether the proposed field connections were correct for the given direction of rotation, the inspector held the free field terminal to one of the armature terminals. Almost immediately the character of the noise that was emitted by the set changed, and it was evident from the drop in the speed that the motor was heavily overloaded. Shutting down the set and feeling of the generator's armature disclosed that it was very hot. Inspection revealed that the generator-bearing lining on the commutator end was melted and had been for some time. As long as the generator was not excited, the bolted coupling was able to hold the armature free from the polepieces; on exciting the field coils, however, the armature was pulled against the polepieces, thereby creating a most efficient brake, which overloaded the motor. E. C. PARHAM.

Brooklyn, N. Y.

Receiver Eliminates Moisture

The illustration shows a home-made air receiver, connected to a Westinghouse air compressor, which has been found efficient in separating the moisture from the air. No moisture is perceptible on the hand held within four inches of the end of the service pipe with the valve wide open. The headers were originally used on an ammonia pipe system and are made of 2½-in. pipe with lugs or saddles for 1¼ pipe attached. The size is of no great importance except that the air velocity through the connecting pipes should be low. The construction may be easily understood by referring to the illustration. The air from this compressor is used in four "dry" sprinkler systems and one "wet" system and also for "blowing out" the generators, so



AIR RECEIVER MADE FROM OLD AMMONIA PIPING

it is highly desirable that the air be as free from moisture as possible. The result has been so satisfactory that I want to pass the suggestion along.

Quincy, Ill. C. L. BOYLE.

Have you been appointed supervisor of illumination in your mill or building? Maybe you have not advised the boss that one is necessary, though your observation of the charts and meters tell you there is.

Inquiries of General Interest

Working Pressures for Pipe, Valves and Fittings—What is the safe working steam pressure for standard and extra-heavy pipe, valves and fittings? S. E.

"Standard" pipe, valves and fittings are assumed to be suitable for working steam pressures not in excess of 125 lb. per sq.in. and "extra heavy" pipe, valves and fittings are assumed to be suitable for working steam pressures to 250 lb. per square inch.

Fluctuation of Electric Pump-Pressure Regulator—The operation of an electrically driven pump is very irregular on account of hammering of the pump that causes continual fluctuations of the pressure regulator and making and breaking of the electric circuit. How can this be remedied? E. E. F.

The pump discharge should be provided with an air chamber for equalizing the discharge pressure, and the pressure connection to the regulator should be throttled so as to dampen the pulsations.

Beveling of Safety-Valve Seat at Angle of 45 Deg.—Why is a safety valve beveled at an angle of 45 deg.? C. V. S.

Valve seats are straight-beveled or rounded, to afford better facilities for grinding the valve to its seat. Beveling at approximately 45 deg. gives a good form for a beveled seat and that angle probably is easier than any other for manufacturers to obtain and duplicate. The adoption of 45 deg. as a standard is purely conventional. Any other bevel might be taken as a standard for safety valves, provided the rated discharge capacities of different diameters are based upon a specified lift and angle of beveling.

Saving by Increase of Feed-Water Temperature—For generation of the same amount of steam at 100 lb. per sq.in. boiler pressure, what per cent. of coal should be saved by increasing the temperature of the boiler-feed water from 50 deg. F. to 150 deg. F.? F. B.

Each pound of the steam generated at 100 lb. boiler pressure, or 115 lb. per sq.in. absolute, would contain 1188.8 B.t.u. above 32 deg. F., and conversion of each pound of the feed water from 50 deg. F. into steam at the pressure would require 1188.8 + 32 — 50 = 1170.8 B.t.u. With the feed water at 150 deg. F. each pound of the feed water would contain 100 B.t.u. more than when the temperature of feed water is 50 deg. F. Hence for each pound of the feed water at 150 deg. F. generated into steam, there would be a saving of 100 ÷ 1170.8 = 0.0853, or about 8½ per cent.

Objections to High Initial Pressure with Light Load—What are the objections to operating a noncondensing Corliss engine with high initial pressure for carrying a light load with very short cutoff? W. H. C.

For given variations of load the required range of governor action will be less and there will be greater hunting action of the governor, accompanied by less regularity of speed, and for derangement of the valve gear the engine is more likely to race from a high than from a low initial pressure with a light load. There also will be less uniformity of rotation during one revolution. Unless compression is adapted to the conditions, the percentage of clearance waste will be higher, because there will be the same volume of clearance space steam of greater density. When the initial pressure is high, with cutoff so short that expansion occurs down to or below atmospheric pressure, the rush of air into the cylinder when the exhaust opens results in cylinder cooling that is detrimental to economy and usually is accompanied by clattering of the exhaust valves and injury to the exhaust valves and their seats.

Heat Value of Fuel and Theoretical Evaporation—What is meant by the heat value of a fuel and the theoretical evaporation per pound of the fuel? J. H. H.

The heat value of the fuel is the number of British thermal units that would be realized by theoretically complete combustion of a pound of the fuel, a British thermal unit (usually designated by the abbreviation B.t.u.) being $^1/_{180}$ of the quantity of heat required to raise 1 lb. of water from 32 deg. F. to 212 deg. F., though in most practical computations 1 B.t.u. is roughly taken as equal to the quantity of heat required to raise 1 lb. of water 1 deg. F. When no other conditions are stated, evaporation is understood to refer to evaporation from water at 212 deg. F. and at atmospheric pressure, commonly expressed as "evaporation from and at 212 deg. F." Evaporation of 1 lb. of water from and at 212 deg. F. requires the latent heat of evaporation, or 970.4 B.t.u. If a fuel has a heat value of 14,000 B.t.u. per pound, the theoretical evaporation from and at 212 deg. F. would be 14,000 ÷ 970.4 = 14.42 lb. of water per pound of the fuel. On account of losses of the fuel through the grates, imperfect combustion, losses of heat by radiation and heat wasted in the chimney gases, the actual evaporation, or evaporative efficiency of boilers, is only 50 to 75 per cent. of the theoretical, depending on the type of boiler and other conditions.

Water Delivered by 4-In. Pipe—What number of gallons per hour will pass through a 4-in. pipe about 1 mile long with the pressure at the entrance 90 lb. per sq.in. and with discharge taking place against a pressure of 45 lb. per sq.in.; and what would be the velocity in feet per minute? D. T.

The velocity of flow will depend on the roughness of the interior pipe surface from construction, corrosion and incrustation. Darcy's formula for loss of head in new cast-iron pipe reduced to English measures is

$$h = \left(0.01989 + \frac{0.001666}{d}\right)\frac{l}{d} \times \frac{v^2}{2g}$$

in which

h = Loss of head due to friction, in feet;
d = Internal diameter of pipe in feet;
v = Velocity per second in feet;
l = Length of pipe in feet;
$2g$ = 64.32.

In the problem, the loss of head due to friction is 90 — 45 = 45 lb., or 45 × 2.309 = about 104 ft.; d = ⅓ ft. and l = 5280 ft. The velocity is to be found by substituting the given values of d and l, and, by assuming different velocities, determining the value for v which will most nearly satisfy the equation. In the example the nearest velocity will be about 4.09 ft. per sec. or 245.4 ft. per min. As the cross-sectional area of 4-in. pipe is 12.566 sq.in., the flow per hour would be $\frac{4 \times 4 \times 0.7854 \times 245.4 \times 12 \times 60}{231}$ = 9611 gal. for new 4-in. cast-iron pipe.

For pipes that have been in use under average conditions h in the formula is to be multiplied by about 1.25 for 5 years' service, by about 1.5 for 10 years' service and by about 1.75 for 25 years' service.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Boiler-Room Efficiencies*

By GEORGE F. WEATON†

Labor conditions make high efficiency more difficult than ordinarily and increase very considerably the operating costs. Suggested equipment for a 1000-hp. plant. Judging combustion by observation of flame through violet glass. Results in the boiler room of a typical manufacturing plant. Discussion on the paper.

SO MUCH does design influence the efficiency possible in the boiler plant that it is desirable to review what is wanted as to equipment. Though a few years ago a plant could be operated at the then standard of economy with simple equipment, this is no longer true. Labor was obtainable at such a wage that the installation of much mechanical apparatus was questionable in plants of fairly large proportions; plants of 1000 hp. and over were seldom provided stokers, coal- and ash-conveying machinery, fuel economizers, mechanical draft, etc. However, the change in labor has been so radical, coupled with its scarcity and high wage, and the difficulties of maintaining discipline and organization in a plant of moderate capacity so extreme, that it is safe to say that no plant of, say, 1000 hp., should be without boiler units of as large a unit capacity as can be installed after considering lay-offs for cleaning, repairs, etc. I should suggest three 350-hp. boilers, fuel economizers, underfeed stokers, coal and ash conveyors and overhead coal storage. Two men could economically operate such a plant; there is boiler capacity sufficient to lay off a boiler for repairs and cleaning, stoker and draft apparatus are sufficient to operate economically above rating and carry the load on the remaining two boilers. The returns on such an investment, although not so much as on a larger plant, will be greater than for a smaller investment for a more simple plant.

Oil Versus Coal as a Fuel

Oil as a fuel at the present here in New England appears as a more or less vigorous competitor of coal. In this section its use will be limited to a few plants. Oil presents many qualities that make it an ideal fuel, such as large overload capacities, cleanliness, no ashes or other bulky material to handle; the handling apparatus is not subject to such rapid deterioration as is coal-handling apparatus; ease of regulating the air supply to the exact amount required for most efficient combustion and small labor requirements.

It appears that oil might be seriously considered in plants of moderate capacity; but the considerations must extend much farther than a tidewater storage for a large plant. Every precaution must be taken against the possibility of cutting off the fuel supply. That a large oil company has storage supply normally of thousands of gallons at tidewater is not sufficient guarantee of unbroken supply to a large consumer. Oil-field labor is mostly turbulent, although not so much might be published about their doings as the coal miners' troubles, oil being of lesser importance than coal as a fuel. Transport by sea is subject to Government requirements, and transport by rail may make oil prohibitive in price. Oil as a marine fuel is used in increasing quantities, and it appears that oil will be the marine fuel of the near future. It will not supplant coal either in quantity or in price as a land fuel unless new and extraordinary fields are discovered. Coal must receive the most consideration by engineers.

Economy in the use of fuel is now being preached as never before. While the sermon is highly commendable, economy should be practiced at all times, not as a war measure only; if it can be done in war time, it can be done during peace. If this war will cause the more general practice of economy, not only in fuel but also in many of our vital resources, the ill wind will blow some good.

Of first importance in the burning of coal is control of combustion; second, the condition of the boiler in respect to cleanliness and repair; third, the condition of the setting in relation to the loss by radiation and the dilution of the gases and cooling of heating surfaces by air leakage.

First, it must be understood that the combustion of fuel is distinctively a chemical process consisting of the rapid oxidation of whatever is combustible, before combustion can take place. The combustible must be brought up to a temperature where chemical union with oxygen will take place; these temperatures vary for different fuels.

Second, there must be available a sufficient and not excessive supply of oxygen heated to the proper temperature, or good results will not be had. Each pound of carbon by theory requires 2⅔ lb. of oxygen, but in practice it is usually calculated that an excess of 40 per cent. is required. In iate plants of good design this excess requirement has been made as low as 20 per cent., and the boiler efficiency obtained is 82 per cent.

Third, the gases from the fuel and oxygen must be brought into intimate physical contact.

The construction of the furnace must be such that these conditions are fulfilled and combustion aided or skill cannot get good results.

The Control of Combustion

In the ideal plant the control of combustion would be as automatic as it would be possible to make it. This requires stokers where the air supply would be controlled by the rate of coal feed, which is in turn controlled by the demand for steam. The coal would be uniform in size and in moisture content. This requires coal crushers and overhead sheltered storage of a supply sufficient for a number of days. The draft should be so regulated that there would be a practically balanced pressure in the setting and out to minimize air leakage in through the setting and escape of gases from the setting. Next, the fireman or man in control of the fires should be among the most intelligent of the plant, and should receive the highest wage of anyone in the plant except the man in charge. He could and would save many times his wage in the average large plant. The great majority of firemen are totally ignorant of the principles of combustion.

Provided we have a well-designed furnace, we can check results by at least four ways; three of these may be termed indicating and one recording. Of the three indicative methods, that of gas analysis is the simplest and the most reliable. Every plant should have at least an Orsat or similar hand apparatus for the determination of the CO_2, CO and O_2 content of the gases. While samples of gas are being drawn, the temperature of the gases should be taken. Carbon-dioxide recorders are desirable but not necessary, as conditions can be fixed and followed from time to time by the hand apparatus, which has the advantage over the CO_2 recorder inasmuch as its gives the CO_2, CO and O_2, which the recorder does not do.

Another method is by judging the colors of the products of combustion in the furnace. Men who have had experience together with the study of the principles of combustion can judge a fire very accurately. For this purpose peepholes are built into the furnace walls and dense violet-blue glasses are used, as it is impossible to observe the color changes with the naked eye. The natural color of the gases when combustion is perfect is a bright red or white-red; it is a haze. After fuel has been thrown on, the gases rising are streaked with a dun-colored opaque gas, indicating that all the combustible gases have not been ignited. This gas, upon entering the combustion chamber, should become transparent as before. These changes cannot

*A paper before the Providence (R. I.) Engineering Society, Dec. 14, 1917.

†Chief engineer, The J. & P. Coats Co., Providence, R. I.

be observed with the naked eye unless the furnace temperature is too low to give efficient thermal results.

When using glasses, the color changes can be observed closely. Imperfect combustion is indicated by dark streaks obscuring the opposite sides of the furnace; perfect combustion by a clear lavender-gray color. Red and yellow flames, which interfere with the naked-eye vision, are cut out by the glass and these rays, when passing adjacent cool surfaces, possess little light that is capable of passing through blue glass. Therefore, perfect combustion takes place at a temperature that will produce light powerful enough to penetrate blue glass, indicating a high actinic power and intense chemical action. The dun-colored gases rising from the fuel bed should, upon entering the zone of perfect combustion, disappear, leaving the clear lavender-gray color.

The third method is by means of the temperature of the furnace. With a room temperature of 60 deg. F., burning one pound of carbon to complete CO_2 will produce a temperature of 5002 deg. F. This in practice is impossible. For good practical results the furnace temperature is from 2800 to 3000 deg. Fahrenheit.

While these checks are indispensable in obtaining good results, the most reliable check is the actual results secured. These can be obtained only by means of metering the feed water fed to the boiler and making allowance for all water blown out of the boiler or used for other purposes if drawn between the meter and the boiler, by accurately weighing the fuel and by periodic temperature readings of the steam, feed water, flue gas, etc., also steam-pressure observations. No plant should be without these valuable adjuncts that give such information, and any plant not so equipped, unless it be very small, will waste enough in a surprisingly short time to pay for the outfit required. Unless results are checked daily and conditions kept at their best by the lessons taught instruments are useless.

Boilers should be cleaned periodically, internally and externally. Cleaning should not be put off until someone thinks it is needed, as the judgment of man is too erratic to be efficient. There have been developed a few good soot blowers, and their installation is desirable. I have yet to find the man that will blow tubes with the steam hose and do it properly unless the ax is held by a thread over his head.

Keep the setting air-tight and well insulated. Brick settings are never tight, and painting will not make them tight, as the paint dries out so rapidly that the expansion and contraction cause it to develop miniature cracks, which, upon close examination, will be found to be caused by like cracks in the setting. If the hand is carefully passed over the setting, the temperature changes felt will show air leakage in a setting thought to be tight. There are some good elastic cements with which settings may be plastered and which do not harden and will maintain a tight setting. Doors set in masonry will be found probably the worst offenders if mortar is depended upon for the joint. Painters' putty applied about the joint and then painted will keep them tight for a long time. These remarks apply likewise to the flues, economizers and chimney—air leaks anywhere cost money.

The Efficiency of Labor Has Fallen

Three years ago it was possible with study and patience to weld labor into an efficient organization. Today it is rather the other way—labor draws the heat. The "efficiency" of boiler-house labor has in three years fallen easily 30 per cent. Three years ago our boiler plant had a manual efficiency, based on time studies, of 60 per cent., and on some operations as high as 70 per cent. All have fallen some, the most decided slump being on the part of the firemen. Coal handlers give the most trouble as to the steadiness of the workers. In the last few months it has been irksome to keep them on the job, and the prospects of holding the efficiency are poor indeed notwithstanding that over 32c. per hour is paid. When it comes to a choice between fuel efficiency and labor efficiency, the labor efficiency must be sacrificed to keep down operating costs.

The following describes the operation of passing coal in the plant I have in mind. Coal is dumped alongside the boiler house on a level with the floor. From here it must be wheeled from 50 to 150 ft., then lifted 8 ft. to the stoker hoppers. Two-wheeled balanced barrows are used with a nominal capacity of 500 lb.; the average load will be about 530 lb. We have had men who by skillful loading would carry 700 lb. to the trip. Loading is done with a No. 5 scoop. If the coal is lumpy, the passer must break it to lumps not larger than his fist to avoid clogging the stoker hopper.

The operator handled on an average for the day 679.32 lb. per trip. This is higher than the average. The distance wheeled was more than 20 ft. over granite-block paving, 15 ft. over brick, up on an elevator and then on 80 ft. of steel plate, from which the coal was dumped into the stoker hopper. The time-study efficiency was 70.26 per cent.; fifty-nine trips were made, the average time per trip including all operations being 7.17 min.; the total coal handled was 40,080 lb. At present five men handle approximately 190,000 lb. in 24 hours, an average of 38,000 lb. each, which gives a cost for handling of about 21.5c. per gross ton. I do not believe that this figure can be reduced under the conditions.

Our operation for the boiler plant is as follows: One boiler is operated Sundays, five additional boilers are fired anew each Sunday night, so six boilers are operated days during the week and four are operated at night excepting Saturday and Sunday nights. The fires in the five boilers are allowed to burn out Saturday afternoon.

For general plant-operating economy the results of the week ending Nov. 10 may be taken as typical:

Total coal consumed (includes coal used for banking and starting), lb.	1,113,670
Total net evaporation, lb	10,435,060
Live steam to mill heating, per cent. 8.45, lb	883,150
Live steam to mill processing, per cent 22.9,	2,389,800
Live steam to mill power generation, per cent. 68.65, lb	7,162,110
Actual net evaporation per pound of coal, lb	9.37
Equivalent evaporation from and at 212 deg. F. per pound combustible, lb	13.1
Kilowatt-hours generated	386,730
Kilowatt-hours, output	354,600
Power coal per kw.-hr. generated, lb	1.98
Total coal per kw.-hr. generated, lb	2.89

The boiler-house percentage charges for the year ending June 30, 1915, with a boiler load factor of 33.45 per cent., were as follows:

Fixed charges	19.45
Management	3.70
Water, lubricants, tools and miscellaneous	0.35
Labor	7.17
Carting ashes and refuse	1.14
Fuel	62.9
Supplies	0.52
Repairs	4.77
Total cost of 1,000 boiler horsepower-hours, dollars	10.58
Cost of 1,000 lb. of steam from and at 212 deg. F., cents	30.67

Eliminating the item of fixed charges, fuel cost was 78.25 per cent of the operating expense.

Actual net evaporation per pound of coal, lb	9.215
Equivalent evaporation from and at 212 deg. F. per lb. combustible, (includes the economizers), lb	12.45
Kilowatt hour output	10,106,750
Coal per kw.-hr., lb	2.165

The cost of 1,000 lb. of steam at 212 deg. F., including all charges is approximately 49c. at present.

Discussion

H. A. Wilcox: I believe that this lack of equipment which Mr. Weaton mentions is due to lack of education on the part of owners and managers as to what could be done in the way of boiler-plant economy. It may safely be stated that managers were and are today unwilling to spend a cent on the nonproducing part of their plants and the boiler plant has, until late years, been considered a necessary evil rather than the heart of the plant. This feeling has gradually undergone a change, due to the entrance of highly trained efficiency engineers into the field and to the retaining of expert engineers by the manufacturers of boiler-plant accessories. These men are capable of bringing clearly into the understanding of managers the benefits to be derived from the installation of their equipment and therefore the use of stokers, coal conveyors, etc., has grown apace. Mr. Weaton ascribes this to the present high wages paid for labor, but I cannot agree entirely with him, as the price of the finished product has advanced correspondingly, leaving as large a margin of profit as in previous years.

It has been suggested that for a plant of 1000 hp. three 350-hp. boilers, economizers, underfeed stokers, etc., should be used. I am inclined to think that this statement is rather broad. The nature of the industry to be served must

be considered, such as: (1) Is 24 hours of operation at 1000 hp. required every day in the week? (2) Will there be exhaust steam available for heating the feed water and can exhaust steam be used in process work? (3) Do the summer and winter loads vary greatly? (4) What provision must be made for future expansion? (5) Is the location of the plant such that it will be able to receive fuel deliveries by rail or by water? (6) Finally, commercial efficiency, based upon the foregoing considerations, will determine the equipment desirable for the plant. By commercial efficiency is meant thermal efficiency properly modified by monetary values. In other words, owing to plant location, nature of the product or like considerations, a plant may be equipped to burn a high grade of bituminous coal of 14,500 B.t.u. and costing $4 per short ton, at 75 per cent. thermal efficiency. This should produce 1000 lb. of steam at a fuel cost of 17.85c. If there is in the same market a poorer grade of coal having 12,000 B.t.u. per lb. and costing $2 per short ton, this same plant should operate at only 68 per cent. thermal efficiency, but would develop 1000 lb. of steam for 11.9c., which shows a fuel-cost saving of about 33⅓ per cent. Considering commercial efficiency, it would therefore seem that a decision for underfeed stokers is somewhat premature before it has been determined whether bituminous or anthracite coal will be used, because underfeed stokers will burn bituminous coal at very high efficiency, while to obtain 68 per cent. efficiency with clear anthracite, such as buckwheat, culm and barley, chain or traveling grates are a necessity.

Assume that these items have all been considered and that the equipment, as outlined previously, has been found most desirable. There is some doubt as to whether two men could operate such a plant economically. I believe that one man would be needed to run the stokers, tend the water, etc.; one man to operate and look after the maintenance of the coal- and ash-handling machinery; and one man for cleaning economizers, cleaning and repairing each boiler as it is laid off, and doing general odd jobs which would naturally develop in a plant of this size. In a plant of several thousand horsepower there is no doubt but that an allowance of two men per 1000 hp. would be ample. In a plant equipped with stokers, however, I think that a plant of only 1000 hp. would require the force enumerated in addition to the chief engineer. I also believe that the installation of stokers, if of the proper type, will materially improve plant efficiency and cut down the payroll as compared with hand-firing.

Use of Oil To Increase

I heartily indorse the opinion that oil appears to be a vigorous competitor of coal, but disagree with the statement that its use in this section will be limited to a very few plants. A few installations in this vicinity named from a long list will serve to illustrate. These plants are not especially selected, but as you will note, vary considerably in size: The Shepard Co., the Boston Store, the Atlantic Mills, Providence; the Lorraine Manufacturing Co., Slater Manufacturing Co., D. Goff & Sons, the Memorial Hospital, Pawtucket; the River Spinning Co., the Nourse Mill, the Social Mill, Woonsocket; and the largest New England mills of the American Woolen Co. are either already equipped to use oil fuel or have contracted for its immediate installation. The "Meypet" list comprised of their New England customers contains the names of 47 plants. I am informed that the oil fields which supply the plants named are located in Mexico and are worked by native laborers who are paid much higher wages than they would receive at their ordinary occupations. It is probably due to these facts that these oil fields have remained entirely unmolested during the recent upheavals in that country. A glance at any reliable newspaper is sufficient evidence as to labor conditions in the coal regions. As to transportation, all are aware of the rapid movement of all kinds of rail shipments. Present activity in shipbuilding indicates that transportation by water, which is the only economical method of supplying fuel oil to the northern and eastern sections of this country, should be facilitated rather than retarded. If this reasoning is correct, we can only assume that shipping facilities from all these fields will grow in direct proportion to their development. So it is likely that after the present emergency oil will be an even greater competitor of coal. I therefore believe that the use of oil as a fuel will largely increase during the next few years in this section as well as in others.

A source of considerable waste, which has not been mentioned, is the loss of combustible through the grates and in cleaning fires. A glance at the ash pile or an analysis of the ash of many plants now in operation will clearly reveal this loss.

Having determined what factors are of prime importance toward attaining maximum fuel economy, the question arises as to how we shall know when we have reached and are maintaing the highest possible standard of economy. The answer is simple: Periodic, frequent layoffs and examinations externally and internally will demonstrate the state of cleanliness and repair of boilers, stokers, economizers, etc., and a frequent analysis of the ash will determine the loss of combustible through the grate. This examination is such an important factor in the maintenance of fuel economy that it should not be beneath the dignity of the chief engineer to make sure that it is properly carried out even if it becomes necessary for him to make a personal investigation.

Importance of Gas Analyses

I am inclined to think that inspection of the fire through violet glasses, as outlined by Mr. Weaton, is not a very reliable indication, by reason of the liability to error in human judgment. I do not wish to be understood that his examination is without any value, as the general condition of the fuel bed with respect to holes, clinker, etc., may be absolutely determined in this way.

Fortunately we have an exact means of controlling combustion, called by Mr. Weaton "Indicating." I believe that a CO_2 recorder and an Orsat are both requisite. There are too many variables entering into combustion to permit of fixing conditions which can be followed for any length of time. Therefore, a recorder or a sampling tank capable of drawing a sample of flue gas over a long period of time is essential; it gives the average operation for any period of time, and any deviation from good practice is at once noticeable. Of course, in the installation of automatic apparatus for the analysis of flue gas it is vitally important that it be so located and arranged that the record of conditions at any one time is made within the least possible interval of time from the occurrence of the conditions. This is to simplify the determination of the causes of any change that may occur. An Orsat should be used from time to time as a check upon the recorder and to determine the location of trouble arising from a deficiency or excess of air, etc. I believe, with Mr. Weaton, that recording instruments giving flue temperatures, drafts, amount of feed water, weight of coal fire, etc., are indispensable aids to fuel economy.

Recommends Heat Balance

These instruments are all valueless unless their indications are intelligently interpreted. An exact interpretation is possible by the use of the heat balance. By the use of the recording instruments mentioned, a heat balance, covering any period of time, may be made and the exact extent and location of any preventable losses readily determined. Steps may then be taken to minimize these losses, a new heat balance made and the result of changes or the amount of improvement will be seen.

The human factor is at least equal to design in importance. By human factor I mean not only the fireman but the management also. Given a plant such as described in Mr. Weaton's paper, I consider that the following additional conditions must exist to develop the highest plant efficiency attainable:

First, the management must be of a type which will take an interest in maintaining the highest boiler efficiency by an intelligent scrutiny of the daily records and a systematic method of keeping after the man on the job; second, the man on the job or chief engineer must be an intelligent and highly paid man—a man who has familiarized himself with the theory and practice of combustion and its control.

May I suggest that a paper by a member of the society

on the general methods of investigating and overcoming preventable wastes in existing boiler plants would be valuable?

Following Mr. Wilcox, F. N. Connet, chief engineer, Builders Iron Foundry Co., Providence, described the installation and operation of the venturi meter. He emphasized the need of freedom from vibration and the desirability of nonpulsating flow for accurate measurement by the meter. This, he said, was given by the centrifugal feed pump. Mr. Connet also mentioned the good effects of feeding water to the boilers so as to anticipate coming loads. He showed several charts, both from the venturi meter (quantity fed) and from recording thermometers recording feed temperatures, to reveal how the average feed temperature was much more constant when steam demands were anticipated by raising the water level during periods of light steam demands and closing off the feed-control valve during heavy demands. It was interesting, he mentioned, that for years design of feed-water regulators had been to give continuous feed, while now design was tending to give periodic feed, with the aim of anticipating demands.

Henry Ballou, of Jenks & Ballou, consulting engineers, Providence, agreed that the many instruments and apparatus mentioned by Mr. Weaton and Mr. Wilcox were desirable, but said it was his observation that 98 out of every 100 average plants did not have them. He spoke of the Manning boiler as one in which air leaks were nil on account of the enclosed firebox. Mr. Ballou said that the use of oil was influenced more by the freedom from labor troubles consequent to its use than by questions of economical combustion. He spoke of the oil-burning plant of the Tamarack Mills, Pawtucket, R. I., which recently went into service and which was designed exclusively for oil. [See *Power*, Mar. 27, 1917, for brief description of this plant. A full description is now in preparation for an early issue of *Power*.]

Charles H. Bromley, associate editor of *Power*, presented many data on the coal and freight (rail and marine) situation, and read a communication from the Bureau of Mines calling attention to current coal containing from 50 to 200 per cent. more ash than in normal times. He dwelt on the futility of getting large returns by attempting to educate the fireman, something that had for years been tried and proved a failure. General adoption of approved furnace design and the employment of highly competent supervision for the boiler-room force were the requirements that held forth the great and only promise in fuel conservation on a large scale.

W. B. Lewis presided. The next paper in the Power Section was "From the Coal Pile to the Lamp," by Jesse E. Gray, chief engineer, Narragansett Electric Light and Power Co., Providence, read Dec. 21.

Deterioration in Heating Value of Coal During Storage

There is a marked agreement in the conclusions reached by the United States Bureau of Mines, as published in Bulletin 136, and the Engineering Experiment Station of the University of Illinois, Bulletin 97, in regard to the effect of storage upon the heating value of coal. The tests show that the deterioration of coal in heating value during storage has commonly been overestimated. Except for the subbituminous Wyoming coal, no loss was observed in outdoor weathering greater than 1.2 per cent. in the first year, or 2.1 per cent. in two years, but the Wyoming coal suffered somewhat more loss—2 to 3 per cent. in the first year and as much as 5.5 per cent. in three years.

In general the conclusion to be drawn from the tests by the Bureau of Mines on New River coal is that under severe conditions of outdoor exposure to the weather it deteriorates in heating value approximately 1 per cent. in the first year, 2 per cent. in the first two years, and not over 3 per cent. in five years. Storage under water prevents practically all deterioration during one year, and no more than 0.5 per cent. has been found in any test for two years or less. Salt water possesses no advantage over fresh water in preventing deterioration. Intermittent exposure and partial drying of the submerged coal probably causes deterioration in some degree, although very small, therefore submergence storage of New River coal is not to be recommended for the sake of preventing deterioration in heat value—its advantage lies only in insuring against spontaneous combustion.

The amount of deterioration of coal from the Pittsburgh beds in one year's open-air storage at the University of Michigan was practically negligible, even in the upper six inches of the exposed coal. During the second, third, fourth and fifth years the deterioration proceeded very slowly and did not reach an amount greater than 1.1 per cent. in five years. The submerged portions may be said to have suffered practically no loss measurable by the degree of accuracy used.

Tests of Pocahontas coal at Panama show that during one year's outdoor exposure it deteriorated very slightly (less than 0.4 per cent.) in heating value, and that the deterioration took place entirely during the first six months (June 15 to Dec. 15). There was a further deterioration of 0.4 per cent. during the second year.

Exposure Increases Weight of Coal

Laboratory experiments have shown that coal ordinarily increases slightly in weight on exposure to the air. It is possible, therefore, that the net losses in heating value may be slightly less than reported, since the actual weight of fuel substance present may be somewhat greater, although its heat value per pound is less than when the coal was stored.

In the storage of Sheridan (Wyo.) coal for more than three months, covering the bins is not as advantageous as the use of air-tight bottoms and sides (of concrete, for example) and the accumulation of a protecting layer of fine slack on the surface. The deterioration of Sheridan coal in heat value can probably in this manner be kept below 3 per cent. in one year, and will probably not increase to more than 4 per cent. in two or three years if the coal remains undisturbed. Physical deterioration (slacking) is also largely prevented in the under portions by the formation of a closely packed layer of slack, at least 12 inches thick on the surface.

Although no indications of spontaneous heating were noted in the tests described, it is found in practice to be dangerous, on account of heating, to store Sheridan coal in piles greater than about ten feet in depth or width. In large masses of coal radiation of spontaneously developed heat is restricted, to a dangerous degree. Submergence under water would probably prove particularly advantageous as a means of safely storing sub-bituminous coal of this type.

Summary of University of Illinois Experiments

The facts established by the investigations by the University of Illinois Engineering Experiment Station may be summarized as follows:

1. Freshly mined coal is chemically very active. Certain constituents have a marked affinity for oxygen, with which they enter into combination at ordinary temperatures. While the extent of this reaction depends upon the variety of the coal and the amount of these active constituents, an important factor is the fineness of division, or the sum total of the superficial areas of the particles, and the accessibility of oxygen to the mass.

2. The actual loss of heat value resulting from storage is small. It is evident that upon mining out the coal from the bed certain volatile constituents of the marsh-gas variety are set free. The heat values represented by such exudations are not great. The tendency to absorb oxygen from the air is also a marked characteristic of freshly mined coal. This is in reality a chemical process, and is accompanied by the generation of a small amount of heat, but these heat losses, compared with the total heat available in the coal, are insignificant. Indeed, it may be fairly questioned whether the heat losses are not more apparent than real, since there is an increase of weight due to the absorption of oxygen. Such increase will in itself lower to a corresponding degree the indicated heat value per pound of coal.

3. There is an increase of "fines" or slack resulting from storage, greater with some coals than with others. This,

together with the saturation of the free-burning constituent with oxygen, slows up the fire and gives the appearance of being lacking in heat value. However, with an increase of draft and a correct understanding of the combustion conditions to be maintained, a most excellent over-all efficiency can be secured even from coals that have been in storage for long periods.

4. Bituminous coal can be stocked without appreciable loss of heat values provided the temperature is not allowed to rise above 180 deg. F. Any method of storage, to be successful, must either check or prevent the absorption of oxygen to such an extent that the generation of heat shall not proceed faster than the dissipation and loss of heat due to absorption or radiation.

5. Under-water storage prevents loss of heat values and is not accompanied by deterioration in physical properties, such as slacking. The water retained by the coal upon removal is substantially only that held by adhesion or capillarity.

6. Dry storage is safer and more satisfactory if the fine material is screened out at the storage yard and lumps only, preferably sized, are stocked.

It will be seen from this summary that the most serious part of the problem relates to the matter of spontaneous heating, and probably the least serious phase relates to deterioration and actual loss of heat values. It is certain that at the present time a better understanding of these difficulties has been reached, and there is reason for believing that this better understanding of the fundamental principles involved will lead to some practicable and safe procedure for the stocking of bituminous coal.

The general summary covering the behavior of the coal in steam generation after six years of storage, as set forth in Bulletin 78 of the University of Illinois Engineering Experiment Station, is as follows: (1) Burning weathered coal is largely a question of correct handling and ignition. Under these circumstances it gives as good results as fresh screenings. (2) Weathered coal requires a little thinner fire and more draft than fresh screenings. (3) When using weathered coal, the fuel bed should not approach any nearer to the water-back than from four to six inches, otherwise trouble with clinker is experienced. (4) Practically as high capacity was obtained with weathered coal as with the other coals used, and, if anything, the fuel bed requires less attention.

Actual Heat Loss Is Small

In this connection attention is called further to the fact that the results obtained and the conclusions presented are based on the heat values in the coal as fired and do not take into account the matter of deterioration. But it has been pointed out that the deterioration is largely apparent in a physical change and that the actual loss of heat value is small. Hence, the efficiency factors developed in the tests may be accepted as fairly representing results obtainable on weathered coal in which the heat loss resulting from weathering is practically negligible.

The facts presented in the bulletin justify the following conclusions: (1) Bituminous coal can be stocked without appreciable loss of heat values provided the temperature is not allowed to rise above 180 deg. F. In fact, there is no appreciable evolution of CO_2 at temperatures below 260 deg. F. (2) The indicated heat loss per pound of coal is due more largely to an increase in weight of a unit mass of coal resulting from the absorption of oxygen than to an actual deterioration or loss of heat units. (3) Freshly mined coal has a large capacity for absorbing oxygen, which combines chemically with both the organic combustible and the iron pyrites present. (4) The combination of oxygen with coal at ordinary temperatures generates a small increment of heat. (5) The rapidity with which oxygen is absorbed depends upon the temperature of the mass and the extent of the superficial area exposed; that is, the fineness of division of the coal. (6) If heat is generated by this slow process of oxidation more rapidly than it is lost by radiation, the acceleration of the reaction causes a rise in temperature which quickly brings the mass up to the danger point. A temperature of 180 deg. F. is named as the danger point because, if the coal reaches that temperature, practically all the free moisture is vaporized and the further rise in temperature will be very rapid. (7) Any method of storage to be successful must either check or prevent the absorption of oxygen to such an extent that the generation of heat shall not proceed so rapidly as to exceed natural heat losses due to radiation. (8) Under-water storage prevents loss of heat values and is not accompanied by deterioration in physical properties, such as slacking. (9) Dry storage is far more safely undertaken if the fine material is screened out at the storage yard and the lumps only, preferably sized, are stocked.

How To Save Coal

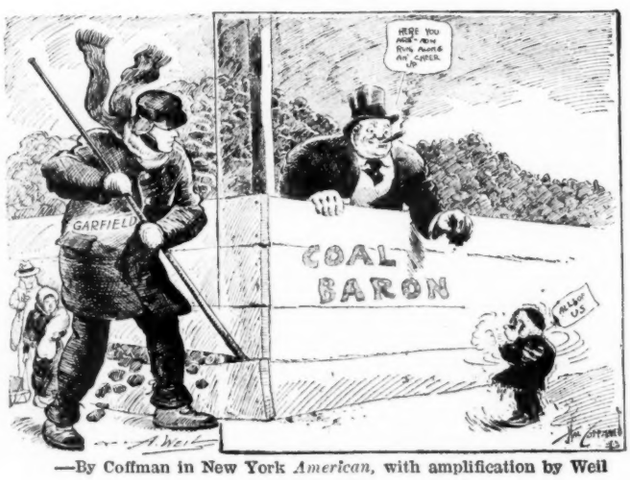
The Bureau of Mines, Department of the Interior, recently asked the advice of a number of prominent fuel engineers as to the best way to conserve in the use of coal. Martin A. Rooney, of Detroit, Mich., has the following to say:

In every trainload of coal hauled from the mines to our coal bins, one carload out of every five is going nowhere and worse. In a train of 40 cars the last eight are dead load that might better have been left in the bowels of the earth.

Every fifth shovelful of coal that the average fireman throws into his furnace serves no more useful purpose than to decorate the atmosphere with a long black stream of precious soot. These are not meaningless statistics nor a "goblin" story, but cold facts on a warm subject. At best, one-fifth of all our coal is wasted. And it is shamelessly and needlessly wasted. Instruments and machinery for getting out all of the heat there is in it are not nearly so complicated nor expensive as the cash register which you use to keep tab on your cash receipts or the truck which you operate to clip a few cents off of your delivery costs. Carbon-dioxide temperature and draft are easier subjects to comprehend than bank discount or freight rates.

The moral is, Mr. Coal Dealer, get busy and learn what they are and how to use them. The time is coming when the Government is going to limit the amount of our coal that is dumped down your chute and in the name of fairness, when we must deny fuel to some manufacturer, let it be to him who cannot show that he is going to use it efficiently. In the name of fairness to the miner who digs it, to the heavily burdened railroad which transports it, to a number of our people whose very existence and whose future happiness depend absolutely on the use we make of this most precious of our resources, let us make efficiency the criterion to judge by when we come to determine which shall survive.

And in fairness to the manufacturer who is patriotically operating his properties at nearly to the breaking speed and who is giving up a large part of his profits for the general good, let the Government show him how to conserve this most important of his raw materials. Let us send into our furnace and boiler rooms men who can show our engineers and firemen how to burn their fuel with the least waste, as we have sent them among our fields and orchards to show the farmer how to increase the productivity of his soil.



—By Coffman in New York *American*, with amplification by Weil

HIS SHARE

Early Action Expected on the Administration's New Water-Power Bill

On the night of Jan. 4, 1918, President Wilson held a conference at the White House with members of various committees of the House of Representatives for the purpose of speeding up action in the House on the passage of water-power legislation. The President committed to the care of Representative Pou, chairman of the House Rules Committee and a member of the delegation whose members conferred with him, a copy of a new water-power bill, to be known as the Administration Bill, which attempts to coördinate water-power legislation proposed for several years past in both Houses of Congress, not only on the public domain, but in navigable streams; and it is expected that the result of the White House conference will be that the House Rules Committee will bring in a rule peremptorily requiring the House of Representatives to vote on and pass water-power legislation at an early date.

What is to take place in regard to water-power legislation in the Senate is not yet known, as that body passed the Shields bill, and there is a difference between the provisions of that measure and those of the Administration measure. The Shields measure, in fact, is by way of amendment to the Act of 1906 to regulate the construction of dams across navigable waters and does not deal with water powers on public lands, which are dealt with by a different Senate committee from the Committee on Commerce, which favorably reported the Shields bill. To the fact that there have been so many committees of both the House and the Senate dealing with so many different phases of proposed water-power legislation has been due, more than to anything else, the delay in passing water-power legislation which was promised the country among the so-called "Administration Conservation Measures" when President Wilson took office five years ago. In the House the red tape which has caused this delay seems in a fair way to be cut by the Presidential conference of Jan. 4; for the President, who has had many conferences with members of the House and Senate and their differing committees, without obtaining legislation, committed the new Administration bill not to the chairmen of any of the House committees dealing with water-power matters, but to the chairman of the Rules Committee. The President is reported by those who attended the conference to have explained with the greatest tact to the committee chairmen that he did not know which committee among the water-power committees to entrust with the bill, in view of their differences, and that he would solve the problem by giving it to the Rules Committee, which, as official Washington views it, carried with it the plain implication: "Pass the bill!"

Senators Expect White House Conferences

Senators in charge of water-power legislation in the Upper House are also expecting to have White House conferences; it is certain that the Administration bill will be introduced in the Senate or that its provisions will come before a Senate committee in some form, so that when the House passes the Administration bill there may be a conference between the House and the Senate, giving opportunity to mold the differences between the Administration bill, the Shields bill already passed by the Senate, and the provisions of any measure relating to the public lands which may come from the Lands Committee of the Senate, in case there is no agreement in the Senate to substitute the Administration bill for the Shields bill. It is not at all certain that Senators will accept the Administration bill, and there are some who will not fail to exercise the "I object" made famous by "senatorial courtesy," unless they can be made to see that the safety of the country imperatively demands the passage of water-power legislation at once because of the shortage of coal and consequently of power, which was President Wilson's impelling motive in committing the new Administration bill to the House Rules Committee.

Although most of the water-power legislation delay has been due to Congress, some of it has been due to opposing views held by members of the Cabinet. These views have now been reconciled in the new Administration bill, which provides for a water-power commission to be composed of three Cabinet officers—the Secretary of the Interior, the Secretary of Agriculture and the Secretary of War. It provides for an executive officer of the commission, who shall be appointed by the President for a term of five years. It provides for the payment of rentals, a feature to which there has never been objection of consequence by any interest, and it grants licenses for water power on public lands as well as public streams for a term of 50 years. At the end of the license period the licensee will be allowed to renew the license and remain in undisturbed possession until the proposed commission shall have done one of three things: First, issue new licenses under laws at that time applicable; second, give licenses to new licensees who shall pay for the fair value of the property; third, take the property over upon paying a fair value, the fair value defined to include all work and main transmission lines plus severance damages for all property not taken over and damaged by reason of severance.

Enhancement of Values Not Provided For

The new Administration measure does not include any allowance for enhancement of values on land, or water rights, or for any good will for a going concern, etc. It provides for alteration, amendment or repeal by Congress, Congress expressly reserving such rights; but in case of alteration, amendment or repeal, such shall not extend to the licensees who have exercised rights or spent money under the bill.

The bill was drawn by General Black and Colonel Keller, of the Army Engineer Corps, representing the War Department; Edward C. Finney, water-power expert for Secretary Lane; former Representative Lathrop Brown, of New York, now a special assistant to Secretary Lane, representing the Interior Department; and O. C. Merrill, chief inspector of the Forest Service, representing the Agricultural Department, who several years ago compiled a mammoth report on water-power companies, their banking affiliations, etc. Present at the White House conference on the night of Jan. 4 were Thetus W. Sims, chairman of the House Committee on Interstate and Foreign Commerce, who has recently succeeded Judge Adamson in that position; Scott Ferris, of Oklahoma, chairman of the House Public Lands Committee; Asbury F. Lever, of South Carolina, chairman of the House Agricultural Committee; Edward W. Pou, of North Carolina, chairman of the House Rules Committee; and Finis J. Garrett, the ranking member of the House Rules Committee. Representative Garrett and Representative Sims, as well as Senator Shields, are Tennesseeans, so that Tennessee will have much to say, it so falls out, as to the passage of water-power legislation by the present Congress.

At the Presidential conference it was agreed that a committee of five members each from the House Committee on Interstate and Foreign Commerce, Agriculture and Public Lands, or fifteen in all, should be created to compose differences as to the various bills which have been under consideration heretofore in the House and to bring together such radical views as have been expressed by Representative Ferris during public debate on water powers with the more moderate views as to water-power development expressed by others. The committee of fifteen, it is felt in Washington, will be materially aided in its labors by the fact that after mature deliberation, advice and conference, President Wilson himself has presented a bill upon which he believes all can agree.

It is gross negligence for the operator of an electric-power plant to permit a switchboard carrying a dangerous voltage to remain exposed near a passageway used by employees, rendering him liable for resulting injury to or death of such an employee. The fact that an employee killed under such circumstances had been warned against the danger of coming in contact with the appliances did not necessarily charge him with contributory negligence where he inadvertently came in contact with the switchboard while stepping aside to avoid another employee who was passing with tools on his shoulder. (Kansas City, Mo., Court of Appeals, Lightner vs. Dunham, 195 Southwestern Reporter, 1055.)

A. S. M. E. Presented with Bust of Admiral Isherwood

At its annual meeting in December, 1917, the American Society of Mechanical Engineers was presented with a portrait bust of Admiral Benjamin Franklin Isherwood, who was for many years, up to the time of his death, an honorary member of the society. The bust was a gift from a number of the friends and admirers of the admiral. The presentation address was to have been made by Commodore George W. Magee, U. S. Navy, who had been an old friend and assistant of Admiral Isherwood; unfortunately, however, Commodore Magee was taken ill, and that pleasant duty devolved upon W. M. McFarland.

Mr. McFarland pointed out that the special glory of Admiral Isherwood's work was that he helped to establish a number of the important basic principles of the science

BUST OF ADMIRAL ISHERWOOD

of engineering. He stated that the first reproduction of actual indicator cards from a marine engine published in any book was in Isherwood's work on "Engineering Precedents," published about 1856. He said further:

His reports of experiments are models of what such reports should be. They include a complete description of the apparatus; and the log of the experiment, in each case, gives all the data which could be observed, whether they were immediately applicable to the purpose of the experiment or not. The result of this is that these reports constitute a mine of valuable information; and other engineers, many years after, seeking information on an entirely different line from that for which the experiment was conducted, find in the complete and careful record just the information they want, and which often can be found nowhere else.

The written address of Commodore Magee, which was read by Mr. McFarland, referred to the great value of Isherwood's experimental work on such subjects as the expansive working of steam, screw propellers, the use of superheated steam and the use of forced draft. Commodore Magee characterized Admiral Isherwood as "the greatest marine engineer who has thus far appeared in our country," and "not only a great engineer, but a great administrator and executive."

Dr. Hollis, president of the A. S. M. E., in accepting the bust on behalf of the society, spoke of his personal acquaintance with Admiral Isherwood at the Naval Academy and said he considered his service for the admiral as perhaps the proudest of his life. Continuing, he said:

I think of him as perhaps the father of our great research laboratories in engineering, as his investigations in connection with steam engines and with boilers preceded all of our schools of mechanical engineering. I think of him also as the father of high speed on the sea. Few people realize that it was Benjamin F. Isherwood who during the Civil War planned and carried to its completion the first ocean greyhound, a ship which went outside along the Jersey coast and made four hundred miles in one day with ease, something that was not equaled again for twenty years.

Annual Report on Locomotive-Boiler Inspection

The annual report of the chief inspector of locomotive boilers for the fiscal year ended June 30, 1917, shows a considerable increase over the previous year in the number of accidents, injuries and casualties due to locomotive-boiler defects and explosions. Much of this increase is explainable on the grounds of the unusual operating conditions, and the shortage of labor and material for suitable repairs. On the other hand, some carriers appeared to consider the use of defective locomotives excusable because of the congestion of traffic. The number of locomotives inspected during the year was 47,452, which is considerably fewer than the year before; and of those inspected, 54.5 per cent. were found defective, an increase of 7.5 per cent. over the previous year. The number of locomotives ordered out of service was 3294. Crown-sheet failures due to low water were responsible for almost three-fourths of the 62 fatalities during the year, and as might naturally be expected, engineers and firemen were the chief sufferers. Of the defects discovered by inspection, broken stay-bolts, faulty injectors and connections, and defective brake equipment headed the list. The report forms another strong argument in favor of the efficient periodic inspection of high-pressure boilers.

An American pipe line played an important part in the recent capture of Jerusalem according to the statement of Maj. Gen. F. B. Maurice, chief director of military operations at the British war office. The campaign which led to the fall of Jerusalem was carried out mainly by British territorial troops supported by small bodies of Australian and New Zealand mounted men and British yeomanry. "In the campaign as a whole," he said, "the great accomplishment has been not the defeat of the Turks, but the conquest of the Sinai Desert. The troops who fought at Gaza drank water from Egypt pumped through an American pipe line and were supplied over broad-gage railroad laid across the 150 miles of the Sinai Desert, which has defeated almost everybody who tried to conquer Egypt for centuries. Every ounce of material for the pipe line, the railroad and the other works came either from Great Britain or from the United States. The fall of Jerusalem was made possible by industry, organization and by the help of material from the United States."

Peat production in Norway in 1914 was 12,000 tons, and 22,000 tons in 1916, but the production in 1917, it is said, will probably go up to 100,000 tons. In Denmark, in 1915, the production was 90,000 tons, in 1916 200,000 tons, and in 1917 it is hoped to produce 500,000 tons. Sweden produced 100,000 tons in 1916. There are 216 peat machines now working in Norway, as compared with 55 in 1916 and 36 in 1914. Among the machines in use are two automatics; these cost £2700 apiece, and can each be handled by two men, the daily output per machine being 30 to 40 tons of peat.—*Gas and Oil Power.*

New Publications

TESTS OF OXYACETYLENE-WELDED JOINTS IN STEEL PLATES

Bulletin No. 98 of the University of Illinois Engineering Experiment Station, by Herbert F. Moore, research professor of engineering materials, treats of tests of oxyacetylene-welded joints in steel plates from 0.14 in. (No. 10 gage) to 1 in. in thickness. Welds made by skilled workmen in a plant especially equipped for oxyacetylene welding were tested for their resistance to tensile, bending and impact stresses. For joints made with no treatment after welding, efficiency for static tension was found to be about 100 per cent. for plates one-half inch in thickness or less and to decrease for thicker plates. When account was taken of the additional thickness at the point of fracture—that is, when the efficiency was computed upon the cross-sectional area of the metal ruptured—the efficiency was not greater than 75 per cent. The joints were strengthened by working the metal after welding and were weakened by annealing at 800 deg. C. (about 1400 F.). Practically the same is true of the bending or repeated-stress test. The impact tests show that oxyacetylene-welded joints are decidedly weaker under shock than is the original material. For joints welded with no subsequent treatment the strength under impact seems to be about half that of the material. If the welded joint is worked while hot, the impact-resisting qualities are slightly improved though this does not make the joint equal to the original material in impact-resisting quality, which is little affected by annealing from 800 deg. C. In general the test results tend to increase confidence in the static strength and in the strength under repeated stress of carefully made oxyacetylene-welded joints in mild-steel plates.

THE J. E. ALDRED LECTURES ON ENGINEERING PRACTICE

A course of lectures on "Engineering Practice" was established about a year ago at Johns Hopkins University through the generosity of J. E. Aldred, and the first series, given by prominent practicing and operating engineers, has recently been published. These lectures, nine in number, present the essential features of planning, construction and operation of modern engineering projects and, being open to the public, were well attended by the engineers of Baltimore.

The subjects in the order in which the lectures were delivered, from Mar. 16 to Apr. 20 inclusive, are as follows: The Operation of a Hydro-Electric Plant, by A. E. Bauhan, station superintendent, Pennsylvania Water and Power Co., Holtwood, Penn.; Some Things Engineers Should Know Concerning the Rudiments of Corporate Finance, Ralph D. Mershon, consulting engineer, New York; The Development of Power from the Standpoint of the Boiler Room, C. F. Hirshfield, chief of research department, Detroit Edison Co., Detroit, Mich.; Power and Service in Industrial Plants, R. J. S. Pigott, superintendent of motive power, Remington Arms Co., Bridgeport, Conn.; Gas Manufacture, Construction and Operation, George P. Marrow, assistant engineer, in charge of Gas Manufacture, Consolidated Gas, Electric Light and Power Co., Baltimore; Rapid Transit Problems in American Cities, George Staples Rice, engineer of the Sixth Division of the Public Service Commission, New York; Some Practical Problems Met With in the Design and Construction of Bridges and Similar Structures, W. W. Pagon consulting engineer, Baltimore; Experimental Engineering, Particularly the Construction of Testing Stations on Water and Sewerage Problems, Langdon Pearse, division engineer, Sanitary District of Chicago; Public Utility Engineering and Finance, Herbert A. Wagner, president, Consolidated Gas, Electric Light and Power Co., Baltimore.

A limited number of paper-bound copies of this course of lectures, about 250 pages 6 x 9 in., including numerous illustrations with additional folders of charts, maps and diagrams inserted, can be obtained from the Johns Hopkins Press (Baltimore, Md.) for $1 each.

Personal

C. P. Coleman was elected president of the Worthington Pump and Machinery Corporation at a meeting of the Board of Directors held on Dec. 31.

R. H. McLeod has been appointed general superintendent of the Philadelphia and Titusville plants of the Philadelphia Rubber Co., being promoted to this position from that of mechanical engineer. He is a graduate of Columbia.

Edward H. Tenney has been promoted from assistant chief engineer to chief engineer of the Union Electric Light and Power Co., of St. Louis, succeeding John Hunter, who is in charge of the Government emergency ship construction of the New Jersey district.

John Hayes Smith, consulting engineer of Milwaukee, has accepted a position as assistant engineer to the Public Service Commission of Pennsylvania. Mr. Smith became associated with the Westinghouse Electric and Manufacturing Co. shortly after graduation from Columbia University, remaining in their employ about six years. He was the first manager of the "Electric Journal," Pittsburgh, and later became editor of the "Electrical Age," New York. He was with the Milwaukee Electric Railway and Light Co. for two years.

Engineering Affairs

The Philadelphia Section of the A. S. M. E. will hold a meeting on Feb. 26, at which Carl G. Barth will present a supplement to "Taylor's Art of Cutting Metals."

American Association of Engineers—Edmund F. Perkins, consulting engineer, Chicago, and president of the American Association of Engineers, will address the New York Chapter of the association at the Hotel McAlpin, on Tuesday, Jan. 15, 8 p.m., on the subject of "National Association Service for Engineers." All interested are cordially invited.

Miscellaneous News

A Four-Inch Tube in a boiler at the Philadelphia Navy Yard blew out on Jan. 1, killing two men, injuring six severely and one slightly. It is believed the explosion was due to a defective tube.

The Boiler of a Freight Locomotive on the Chesapeake and Ohio R.R. exploded at Marmet, W. Va., on Dec. 22, killing the fireman and injuring the engineer. The cause of the explosion is not known.

A Boiler Exploded at the plant of the Beaver Clay Co., at New Galilee, Penn., on Dec. 26, causing considerable damage to the boiler room and surrounding structure and severely injuring a workman who was near the boiler when it let go. The cause of the explosion is not known. The damage done was estimated at $2000. Because of a partial suspension of work during the Christmas period many of the employes were not in service, which fortunately accounts for lack of casualties perhaps.

Large Providence Turbine Started—The 45,000-kw. Westinghouse cross-compound turbine at the South Street Station of the Narragansett Electric Lighting Co., Providence, R. I., was started for the first time Wednesday morning, Jan. 9. The turbine is perhaps the largest in the world in point of dimensions, although the two-cylinder turbine at the Duquesne plant, Pittsburgh, is of the same capacity. The Providence turbine has a double-jet Leblanc condenser, which "Power" will describe after it has been in service long enough to determine what performance it will give.

U. S. Requisitions Power Plants at Niagara Falls—In order to assure an adequate supply of power for establishments engaged in war work at Niagara Falls and Buffalo, the Government has requisitioned the electric power produced, imported and distributed by the Niagara Falls Power Co., the Hydraulic Power Co. of Niagara Falls and the Cliff Electrical Distributing Co. Canadian demands that approximately 100,000 hp. of current imported from the Canadian side be applied exclusively to war work were said to have been a determining factor in the Government's decision to requisition all power. About 110 factories not working directly on war contracts will be obliged to curtail their power somewhat and use it at times when munition factories are making their smallest demand. They will also substitute steam for electricity as much as possible.

England Out of Gasolene?—Our London correspondent writes: "Apparently while you are not short of petrol, we in England are. Instead we use gas, a bag to contain a charge being placed on top of the lorry, omnibus or other vehicle. Depending on the thermal value of the gas, the equivalent is about 250 cu.ft. to the gallon of petrol. Some busses have gas bags to hold about 700 cu.ft. In one instance, motor busses carrying 35 people run a mile on 60 cu.ft. Compression of gas has been suggested, but this means special machinery and special cylinders to support the increased pressure. The cost of charging varies according to the district. To take Birmingham as an example, the minimum fee is 1s. (25c.), this being the cost of 250 cu.ft. of gas." It seems likely, therefore, that gasoline engines, whether for automobiles, stationary, electric-generating or pumping sets, are now compelled to use gas.

Business Items

The Ridgway Dynamo and Engine Co., of Ridgway, Penn., has appointed the Blake Electric Manufacturing Co., 1 Rowes Wharf, Boston, Mass., as its sales representative for the New England States.

The Little Giant Truck Co. is the name of what was formerly the motor-truck department of the Chicago Pneumatic Tool Co., which on account of its growing proportions has branched off as a separate organization. The new company is owned and controlled by the Chicago Pneumatic Tool Co.

Albany Grease is celebrating its fiftieth anniversary. In 1868 the Albany Lubricating Compound and Cup Co. was founded at Albany, N. Y., by Adam Cook. The name Albany Grease was given to Albany Lubricating Compound by the engineers of the country, who quickly gave it a name of their own make. In four years the small plant at Albany became too small to take care of the business, and in 1872 larger quarters were secured along the river front at 231 West St., New York City. Nine years later the business was moved to still larger quarters at 313 West St. Still the business grew, until, by the purchase of neighboring warehouses, the Albany plant extended clear through the block from West to Washington St. After a stay of 30 years the West and Washington St. plant was abandoned, and the modern commodious plant at 708-10 Washington St. was placed in service. Many satisfied customers unite in wishing Albany Grease many happy returns of the day.

Trade Catalogs

Files Hand Stoker. The Files Engineering Co., Inc., Providence., R. I. Catalog. Pp. 8; 6 x 9 in.; illustrated.

Ellison Draft Gages. Lewis M. Ellison, 214 Kinzie St., Chicago, Ill. Pamphlet. Pp. 36; 3½ x 6 in.; illustrated.

Westinghouse Motors and Generators for Direct-Current Circuits. Westinghouse Electric and Manufacturing Co., E. Pittsburgh, Penn. Catalog No. 30. Pp. 78; 8½ x 11 in.; illustrated.

Getting Maximum Pulley Efficiency. The American Pulley Co., Philadelphia, Penn. A pamphlet containing data and information compiled by this company relating to belt pulleys. Pp. 38; 6 x 9 in.; illustrated.

Falls Automatic Engine Stop. Falls Machine Co., Sheboygan Falls, Wis. Catalog. Pp. 24; 6 x 9 in.; illustrated. This contains information regarding the operating of overspeeding engines and shows application of engine stops.

Reverse-Phase Circuit Breakers. The Palmer Electric and Manufacturing Co., Boston, Mass. Bulletin M1; pp. 4; 6 x 9 in.; illustrated. Describes circuit-breakers for protection of polyphase motors against single-phase and reverse-phase operation.

Just About Boilers is the title of a pamphlet issued by the Badenhausen Co., 1425 Chestnut St., Philadelphia, Penn., which gives comparisons of principles of current boiler designs and details of construction of the Badenhausen boiler. Pp. 32; 8½ x 11 in.; illustrated.

Electric Welding. The Wilson Welder and Metals Co., 52 Vanderbilt Ave., New York. Catalog No. 2. Pp. 64; 6 x 9 in.; illustrated. This describes in detail the Wilson electric welding system and specially prepared metals. Blueprints showing layout of complete equipment are included.

Automatic Pumps and Receivers. Worthington Pump and Machinery Corp., 115 Broadway, New York. Bulletin D-1301. Pp. 12; 6 x 9 in.; illustrated. Describes a number of types of apparatus manufactured by the Deane Works of the Worthington corporation for maintaining free and unobstructed circulation of steam in heating systems and machinery using steam.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Jan. 10, 1918	One Year Ago	Jan. 10, 1918	One Year Ago
Buckwheat	$4.60	$2.05—3.20	$7.10—7.35	$3.25—3.50
Rice	4.10	2.50—2.65	6.65—6.90	2.70—2.95
Boiler	3.90	.....	.....	.....
Barley	3.60	2.20—2.35	6.15—6.40	2.35—2.60

BITUMINOUS

Bituminous not on market.

	F.o.b. Mines*		Alongside Boston†	
	Jan. 10, 1918	One Year Ago	Jan. 10, 1918	One Year Ago
Clearfields	.....	$3.00	.....	$4.25—5.00
Cambrias and Somersets	.....	3.10—3.85	.....	4.60—5.40

Pocahontas and New River, f.o.b. Hampton Roads, is $4, as compared with $2.85—2.90 a year ago.

*All-rail rate to Boston is $2.60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Jan. 10, 1918	One Year Ago	Jan. 10, 1918	One Year Ago
Pea	$5.05	$4.00	$5.80	$6.00—7.00
Buckwheat	4.30—5.00	2.75	5.50—6.00	5.50—6.00
Rice	3.75—3.95	2.20	4.50—5.00	5.00—5.50
Barley	3.25—3.50	1.95	4.00—4.25	3.75—4.00
Boiler	3.50—3.75	2.20	.....	.....

Bituminous smithing coal, $4.50—5.25 f.o.b.
Quotations at the upper ports are about 5c. higher.

BITUMINOUS

	F.o.b. N. Y. Harbor	Mine
Pennsylvania	$3.65	$2.00
Maryland	3.65	2.00
West Virginia (short rate)	3.65	2.00

Based on Government price of $2 per ton at mine.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide		Independent
	Jan. 10, 1918	1 Yr. Ago	Jan. 10, 1918	1 Yr. Ago	1 Year Ago
Buckwheat	$3.15—3.75	$2.00	$3.75	$2.90	$4.15
Rice	2.65—3.65	1.25	3.65	2.15	3.35
Boiler	2.45—2.85	1.10	3.55	2.00	....
Barley	2.15—2.40	1.00	2.40	1.90	2.35
Pea	3.75	2.80	4.65	3.70	....
Culm	....	....	....	....	1.25

Chicago—Steam coal prices f.o.b. mines:

Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.65—2.80	$3.10—3.25
Mine-run	2.40—2.55	2.85—3.00
Screenings	2.15—2.30	2.60—2.75

Smokeless Coals	So. Illinois, Pocahontas, Pennsylvania and West Virginia	Hocking, East Kentucky and West Virginia Splint
Prepared sizes	$2.60—2.80	$3.05—3.25
Mine-run	2.40—2.60	2.40—2.60
Screenings	2.10—2.30	2.10—2.30

St. Louis—Prices pet net ton f.o.b. mines a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Jan. 10, 1918	One Year Ago	Jan. 10. 1918	One Year Ago	Jan. 10. 1918	One Year Ago
6-in. lump	$2.65—2.80	$3.50	$2.65—2.80	$3.50	$2.65—2.80	$3.50
2-in. lump	2.65—2.80	....	2.65—2.80	....	2.65—2.80	3.25—3.50
Steam egg	2.65—2.80	3.50	2.65—2.80	3.50	2.65—2.80	3.25—3.50
Mine-run	2.40—2.55	3.50	2.40—2.55	3.25	2.40—2.55	3.00—3.25
No. 1 nut	2.65—2.80	3.50	2.65—2.80	3.50	2.65—2.80	3.50
2-in. screen	2.15—2.30	3.25	2.15—2.30	3.25	2.15—2.30	3.00—3.25
No. 5 washed	2.15—2.30	3.25	2.15—2.30	3.00	2.15—2.30	3.00

Williamson Franklin rate St. Louis, 87½c.; other rates, 72½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Lump and Nut	Slack and Screenings
Big Seam	$1.90	$2.15	$1.65
Pratt, Jagger, Corona	2.15	2.40	1.90
Black Creek, Cahaba	2.40	2.65	2.15

Government figures.

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same as the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Ariz., Kingman—The Desert Power and Water Co. plans to extend its transmission line to the Hackberry Consolidated Mill. Estimated cost, $90,000. A new line will also be extended to the Cyclopic, near Chloride. F. A. Wilde, Jr., Mgr.

Calif., Los Angeles—City has plans under consideration for the erection of power plant No. 2 in San Francisquita Canyon. W. Mulholland, Ch. Engr. Estimated cost, $750,000.

Calif., Mare Island—(Vallejo P. O.)—(Official)—The Bureau of Supplies and Accounts, Navy Dept., Wash., will soon receive bids to deliver at Navy Yard, Mare Island, under Schedule No. 1639, 400,000 ft. plain bell wire.

Iowa, Eddyville—City plans an election soon to vote on $7000 or $8000 bond issue for improvements to the electric-lighting system.

Mass., Boston—(Official)—The Bureau of Supplies and Accounts, Navy Dept., Wash., will soon receive bids for delivering at Navy Yard, Boston, under Schedule No. 1640, brass gate valves, flanged gate valves and globe angle flanged valves.

Mass., Ipswich—The Newburyport Gas and Electric Co. plans to build a transmission line through certain streets in the city. C. S. Spaulding, Newburyport, Supt.

N. C., Graphiteville—The General Graphite Co., Birmingham, Ala., plans to build a hydro-electric plant here. Estimated cost, $75,000.

N. J., Jersey City—The American Sugar Refining Co., 117 Wall St., New York City, is having plans prepared for the extension and alteration of its power house on Washington St. Estimated cost, $10,000.

N. J., Newark—The Butterworth-Judson Co., Roanoke Ave., plans to build a 1-story, 87 x 94-ft. boiler house. Estimated cost, $18,000.

N. Y., Andover—City has plans under consideration for the erection of an electric-lighting plant.

N. C., Tuxedo—The Blue Ridge Power Co. plans to build a hydro-electric plant on the Green River. Estimated cost, between $800,000 and $900,000.

Penn., Philadelphia—Shane Bros. & Wilson, Bourse Bldg., is having plans prepared by J. M. Whitham, Arch., for the erection of a new 1-story, 35 x 40-ft. power house in connection with its plant on 63rd and Market Sts.

Penn., Pottsville—The Eastern Pennsylvania Light, Heat and Power Co. has petitioned the Public Service Commission for permission to issue $10,500 in bonds; the proceeds will be used in improvements to its system. W. B. Rockwell, Mgr.

Penn., Philadelphia—The United States Government plans to build a 1-story power house at the Frankford Arsenal.

Penn., Reading—The Reading Transit and Light Co. has been granted permission to issue an appropriation of $150,000; the proceeds will be used in extensions and improvements to its system. W. S. Barstow, Mgr.

Penn., West Chester—The Philadelphia Suburban Gas and Electric Co. plans to build a transmission line from its electric plant on the Schuylkill River at Crombie to Coatesville. J. D. Shattuck, Philadelphia, Mgr.

Penn., White Haven—The Wilmot Engineering Co., Hazleton, plans to build several additions to its plant including new power stations.

Tex., McAllen—The Rio Grande Public Service Corporation plans to install new machinery and equipment in its electric-lighting and power plant. Estimated cost, $40,000.

Tex., San Benito—The Commonwealth Electric Light and Water Co. plans to enlarge its power house and install new equipment including a new 100-hp. engine in its electric-light and power plant here.

Wash., Puget Sound—(Bremerton P. O.)—(Official)—The Bureau of Supplies and Accounts, Navy Dept., Wash., will soon receive bids for delivering at Navy Yard, Puget Sound, under Schedule No. 1641, low pressure, iron, steam and water unions and brass composition, steam and water unions.

B. C., Trail—The West Kootenay Power and Light Co. plans to extend its transmission line to the plant of the Canada Copper Co., Princeton, about 110 miles. J. B. McDonald, Rossland, Gen. Supt.

Ont., Bartonville—Barton Township plans to purchase electrical equipment. Estimated cost, $55,000.

Ont., London—The Board of Utilities plans to build a brick and steel addition to its hydro sub-station. Estimated cost, $35,000. E. V. Buchanan, City Hall, Gen. Mgr.